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FARMERS' BULLETINS
Nos. 1726-1750

WITH CONTENTS

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U. S. DEPARTMENT OF AGRICULTURE
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FARMERS' BULLETINS

Nos. 1726-1750

WITH CONTENTS

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U. S. DEPARTMENT OF
AGRICULTURE
FARMERS' BULLETIN No. 1726

TREATMENT AND CARE OF TREE WOUNDS

QUESTIONS CONCERNING the proper treatment of wounds in shade, ornamental, roadside, street, and park trees (often long-neglected wounds) are being constantly received by the Department of Agriculture. This bulletin was designed to answer such of these questions as have been most frequently asked. It is intended primarily for persons in charge of private or public property with little or no knowledge concerning the normal life processes of a healthy tree nor of why and how wounds endanger the health of trees.

Well-established tree-surgery firms, located in various parts of the country, are prepared to handle all grades of tree work ranging from the simplest to the most complicated. Many of these have their own special methods, which in expert hands are usually quite satisfactory. There are many persons, however, who prefer, either from choice or necessity, to attend to the wounds in their own trees, and the information in this bulletin is intended to serve as a guide for such persons. Most of the simpler types of work are entirely within the range of almost any practical man who is familiar with the use of a saw, gouge, mallet, and paintbrush.

Two axioms that should be borne in mind constantly are (1) that prompt treatment of freshly made wounds is the surest and best method of preventing disease or decay and needless expense in the future, and (2) that all old wounds should be treated as soon as possible by some method similar to those described in this bulletin.

The following bulletins give information on the selection, planting, and care of trees for shade and ornamental purposes: Farmers' Bulletin 1087, Beautifying the Farmstead; Farmers' Bulletin 1208, Trees for Town and City Streets; Farmers' Bulletin 1209, Planting and Care of Street Trees; Farmers' Bulletin 1481, Planting the Roadside; Farmers' Bulletin 1482, Trees for Roadside Planting; Farmers' Bulletin 1591, Transplanting Trees and Shrubs; and Farmers' Bulletin 181, Pruning. They may be purchased from the Superintendent of Documents, Washington, D.C., for 5 cents a copy.

This bulletin is a revision of and supersedes Farmers' Bulletin 1178, Tree Surgery.

Washington, D.C. Issued August 1934

TREATMENT AND CARE OF TREE WOUNDS

By J. Franklin Collins, formerly *senior pathologist, Division of Forest Pathology, Bureau of Plant Industry*

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NEGLECTED WOUNDS

WOUNDS OF ALL SORTS are so common on trees that most people have become oblivious of the damage arising from neglected wounds, or at least they underrate the possibilities of damage. Every broken limb and every other kind of external wound that penetrates to the inner bark may allow active plant or animal parasites or rot-producing organisms to enter unless these injuries receive prompt and proper treatment and care.

The best, safest, and most economical means of preventing future extensive decay, disfigurement, or premature death of a tree is to attend to each wound as soon as it occurs. This kind of work is simple and comparatively inexpensive. If a wound is allowed to remain untreated for some years (as commonly happens) decay-producing organisms almost invariably enter and produce a rotted area in the wood beneath, often so extensive that a violent wind may break the tree at the decayed and weakened spot. Roadside trees weakened by decay are especially dangerous to traffic. Uninjured bark or prompt and proper treatment of an injured area usually prevents the entrance of organisms causing decay.

If an untreated wound of several years' standing has developed a considerable area of decayed wood or bark, the first question to be considered is whether the tree or limb involved is of sufficient value to warrant the expense of properly treating it. Should it be decided to undertake the work, the too common mistake of neglecting portions that are difficult to reach should not be made. Under ordinary conditions it should be a thorough, complete, and sanitary job, or else nothing whatever should be attempted. If a tree is badly decayed or injured, it may be better to remove it and set a healthy one in its place; or it may be braced or guyed to prevent breakage in a violent storm; or the decayed matter may be removed and the cavity treated in accordance with directions given in this bulletin. When large areas of rotted wood have been excavated and the cavities either filled or left open, the wounds will rarely heal completely. Careful and thorough cavity work on the trunk of a tree is of much greater importance than on a limb, primarily because the limb often may be cut off later well behind the diseased area, if need be, without materially impairing the general health of the tree.

Many people still fail to realize the full extent to which properly located, healthy, and well-kept trees enhance the value of real estate, particularly for residential purposes. From this point of view alone, it is wise to keep trees in a healthy and vigorous condition. Oftentimes historical association, scientific value, economic importance, or rarity of the species outweighs all other considerations. For various reasons trees are unquestionably a real asset whether on private, semiprivate, or public property, including highways and streets.

It costs comparatively little to treat recent wounds properly. Such treatment contributes greatly to the health, beauty, usefulness, and value of the trees in years to come. This is one of the great economic lessons connected with the care and treatment of trees.

Occasionally in this country, but more frequently in Europe, an old or irregular cavity is regarded as more ornamental and picturesque if left untreated. Undoubtedly the inrolling callus in such cavities contributes very materially to the strength of the trunk, in much the same manner that H- and I-beams strengthen a building or a bridge. It is usually advisable to reduce the size of the crown when a trunk is much weakened by decay, whether or not the decayed matter is removed and the cavity filled. This is done by cutting off a considerable portion of all the main limbs, which produces a more compact crown and lessens the strain on the weakened trunk.

STRUCTURE AND LIFE PROCESSES OF TREES

In order to undertake intelligently any cutting of tissues on an injured tree it is essential that one should know something about the normal life processes of a healthy tree and how mechanical injuries, decay, and cutting affect these processes.

A tree is composed of three main parts—the root, the stem, and the leaf. The root and stem are composed of the bark, the cambium, and the wood.

ROOT

The general structure of any large root is essentially the same as that of the stem, which is described below. The root and its many branches serve not only for anchorage, but also as passages for the entrance of water into a tree. Practically no water enters elsewhere. It enters chiefly through the root hairs and very small root branches, passes into the larger root branches, then up the trunk and out through the larger and smaller branches to the leaves.

STEM

A cross section of the stem or trunk, a large branch, or a root of almost any of our common trees shows that the bulk of it is composed of a central cylinder of wood surrounded by a comparatively thin mantle of bark (fig. 1).

BARK

The bark is composed of two parts; the dry outer corky bark (fig. 1, *a*), and the moist inner or living bark (fig. 1, *b*), both of which are made up of cells and tubes running lengthwise in the branches, trunk, and roots. The outer bark is dead bark tissue serving mainly as a protecting layer for the underlying living bark. It is doubtful whether organisms that cause decay can ever pass through an unbroken corky outer bark. It is through the inner bark that most of the transfer of organic food from the leaves to various parts of the tree takes place. Any injury to the living inner bark will react unfavorably on the general health of the tree. Such unfavorable reaction may be slight and imperceptible, or very pronounced, depending upon the severity of the injury and the ability of the particular tree to overcome that particular type of injury.

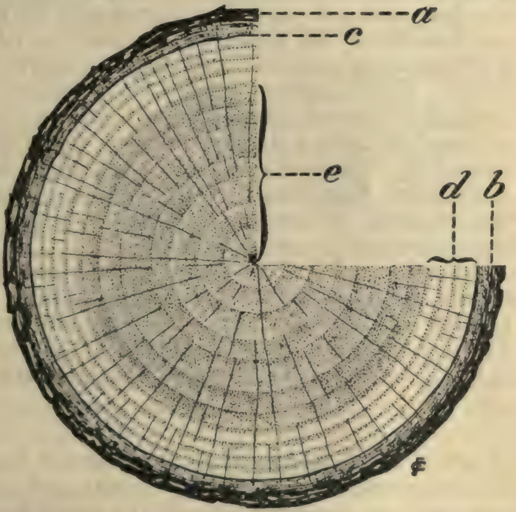

FIGURE 1.—Cross section of a typical tree trunk, showing the various parts: *a*, Outer corky bark; *b*, inner living bark; *c*, cambium; *d*, sapwood; *e*, heartwood. The concentric rings in the sapwood and heartwood are the annual rings. The radial lines extending part way or entirely from the center to the bark are the pith rays. In this figure the outer and inner bark are represented as approximately equal in thickness.

WOOD

The woody cylinder of the older trees, as seen in cross section, is commonly divided into two more or less well-defined regions, an outer lighter colored cylinder known as the sapwood (fig. 1, *d*) and an inner darker colored cylinder known as the heartwood (fig. 1, *e*). Sapwood and heartwood are not always distinguishable by color, however, and at times heartwood may be absent. Upon closer examination of the end of a section of most of the common trees of the Temperate Zone, it is generally possible to distinguish numerous concentric rings (often more or less irregular) throughout the sapwood and heartwood. These are known as annual rings (fig. 1), because under normal conditions a new one is formed each year.

The heartwood may be regarded as dead or nonconducting tissue which is useful mainly in giving rigidity or stiffness to the tree. This explains why the heartwood often can rot away, or be entirely removed, without causing serious injury other than impairing the strength of the tree. Most of the transfer of water from the soil to the leaves takes place through the sapwood.

CAMBIUM

Between the inner bark and the sapwood in all healthy parts of a tree there is a very thin continuous layer of young (embryonic) tissue, which is not necessarily sharply marked off from either bark or wood. This is the cambium (fig. 1, *c*). It is this layer that splits or slips so easily in the springtime when the bark is removed to make the familiar willow whistles of boyhood days. During the growing season its microscopic elements (cells) are constantly dividing and giving rise to new layers of cells on both sides, on the outer side of the cambium to new layers of bark, on the inner to new layers of wood. Thus, the youngest layers of both bark and wood are those adjoining the cambium. As the cambium is a very tender and thin-walled tissue, a comparatively slight injury will kill portions of it; and, once killed, the dead area can never again grow new bark or new wood. However, the healthy living cambium around the edges of the dead area will give rise each year to a new layer of more or less abnormal bark and wood. Under normal conditions these new layers of bark and wood (called callus bark and wood) will grow out each year over the margin of the dead area a little more than the width of an annual ring, and eventually the dead area, if not too large, may be entirely overgrown and hidden from view. Such dead spots furnish favorable places for the entrance of insects and organisms causing decay unless they are promptly and properly treated.

All new layers of the normal bark and wood of roots, trunk, and branches originate in the living cambium, never elsewhere. Consequently it is of the utmost importance to keep the cambium in a healthy and uninjured condition at all times. Diseases or injuries that kill large portions of the cambium usually kill the tree.

LEAF

Green leaves of the ordinary type are familiar to everyone. They are composed of veins made up of conducting tubes or tissues continuous with similar tissues in the wood and bark, while between the veins are several or many layers of variously shaped microscopic cells, which are specially adapted to perform the physiological functions that are essential to every living plant. Leaves are the structures or laboratories in which the organic food of the plant is manufactured from the inorganic food elements. Also they are the organs through which most of the water taken up by the roots is evaporated; furthermore, it is the leaves that are most active in absorbing oxygen and giving off carbon dioxide in the process of respiration, a process that is as necessary for all plants as it is for animals, and for analogous reasons.

WATER REQUIREMENTS

The water that enters a tree through the roots is not pure, but is a weak solution of many of the chemical substances found in the soil. When it reaches the leaves a very large proportion of it is given off in the form of a vapor of pure water. The chemical substances in solution are not evaporated. This means that practically all the chemical substances remain in the tree. As these enter the root in a very weak solution a relatively large amount of water must pass through the plant and be evaporated, in order to accumulate the chemical substances that are to be utilized later in various ways as needed, or segregated and stored as useless or injurious substances.

Authentic records of many observers show that trees need a large amount of water to keep them in a healthy condition. A single oak tree is known to have given off into the air in the form of vapor more than 100 tons of water in a single growing season, and an acre of small beech trees more than 1,000 tons in a single season. Similar records show that an apple tree 30 years old gave off approximately a barrel of water each day, and a good-sized birch tree two barrels of water on a hot summer day. Other estimates show that the evaporation of 200 to 500 pounds of water is required for every pound of wood (dry weight) that is produced; also that a square yard of leaf surface commonly evaporates from half a pound to a pound of water each hour on a hot day. These figures give an idea of the amount of water that may be evaporated by certain trees, and of the importance of water to a tree.

Throughout the growing season this water flows continuously from the roots through the sapwood to the leaves. Unless the amount of water lost by evaporation (transpiration) is promptly, fully, and continuously replaced by water taken in by the roots, the foliage may wilt. Should this wilted condition continue for any great length of time the tree, or portions of it, may be permanently injured. If the wilting is slight or of short duration the injury may be temporary and subsequent recovery prompt, but if considerable or long continued it may cause serious injury or death. Severe injury also may result from a partial lack of water, particularly if long continued, where no obvious wilting of the foliage results. Examples of this type of injury may be seen after long-continued drought, or in the case of trees that normally require considerable water when they have been planted in dry situations or in sandy soil considerably above the water table. Roadside trees often suffer particularly from lack of water on account of the abnormal conditions under which they grow, the normal water table often being lowered by the highway surfacing and the construction of sidewalks, curbs, and gutters.

Wilting or injury may result not only from an actual lack of water in the soil but also from certain abnormal conditions when there is water in abundance in the soil, such, for example, as a sudden application of salt water (perhaps from an ice-cream freezer) or certain other chemical substances around the roots; or it may result from mechanical injury to the sapwood, or the removal of considerable portions of it, or from the cutting of roots, or from the clogging or drying out of the water-conducting tubes either in the stem or root as a result of disease, or from other abnormal conditions that interfere with the free transfer of soil water. Calcium chloride applied in excess as a dust palliative or temporarily stored along roads may injure trees.

If any great width of sapwood, as measured around the trunk, is removed or becomes useless through disease or injury, the tree may be seriously injured or killed, at least above the wound. Since the water from the soil moves upward primarily through the microscopic tubes in the sapwood, which run lengthwise in roots, trunk, and limbs, it is possible to remove a long and narrow strip of sapwood extending parallel with these tubes with less injury to the tree than would result from cutting out a shorter but broader area to an equal depth. This is due to the fact that the broader cut severs and renders useless a greater number of these active water-conducting tubes.

As already stated, water necessarily has to be evaporated in enormous quantities in order that the needed chemical substances may be accumulated in a tree. Water also forms an important constituent in all tissues of a living tree. The approximate amount (in percentage) of water recorded for some of our shade trees under ordinary conditions will be of interest here: e.g., black locust, 28 percent; white ash, 30 percent; white cedar and black cherry, 36 percent; shagbark hickory and sugar maple, 37 percent; beech, 38 percent; white oak, 40 percent; red maple and loblolly pine, 41 percent; white pine, 43 percent; sweet gum, 45 percent; sycamore and red oak, 46 percent; American elm, 47 percent; aspen, 50 percent; incense cedar, eastern hemlock, and jack pine, 52 percent; cottonwood, 53 to 57 percent; evergreen magnolia and balsam fir, 54 percent; chestnut, 55 percent; and white fir, 61 percent. These figures still further emphasize the importance of water to a living tree.

Young trees that have been recently set usually need artificial watering at least for 2 or 3 years during dry seasons. Other trees often require it in order to keep them in a healthy condition, or to help overcome the effects of injury, disease, pruning, or cavity work. The amount of water needed varies according to local conditions, such as slope, soil, exposure, etc. As a rule the best results from artificial watering during a dry season will come from a copious watering not oftener than once or twice a week, rather than a little every day, but apparently this rule is not without exceptions.

To accomplish the most good the watering should continue until the soil surrounding the small feeding roots is throughly soaked. One simple way of determining this condition is to apply a considerable quantity of water (perhaps estimated by the time the water has been running) and, after allowing it to soak in throughly, dig a hole with a trowel or spade, and note the depth to which the water has penetrated. With most trees, under normal conditions, it should penetrate at least a foot at each watering. This will represent a much greater quantity of water than most people realize. It may be necessary to dig a second (or third) hole in order to determine when the requisite amount of water has been applied; if so, the second hole should be made at least a short distance from the first one, so as to determine the penetration of water through the previously undisturbed soil. Another watering should be given as soon as the soil becomes dry enough to crumble readily between the fingers. This may be from 2 or 3 days to 3 or more weeks. When the amount of water required to reach the roots has been determined for a certain place and also the time it takes for the soil to dry out again, the data will be available for roughly estimating the quantity of water needed, as well as the frequency of its application, provided all conditions under which the tests were made remain approximately the same. The water in the soil may be conserved by loosening the surface soil with a rake or harrow as soon as the surface becomes sufficiently dry to permit it after each watering, or by applying a mulch of straw, leaves, or other suitable material.

In certain situations, particularly where there is a sod or the soil is hard-packed or the surface area of dirt is very limited, as often occurs between the sidewalk and the street pavement or between walks and walls elsewhere, one way to water the roots is to insert short tile drainpipes vertically in the soil and turn the water into these. If this method is adopted, the tiles should be from a foot to 18 inches or more long and 2 to 5 inches in diameter, with the top practically at the ground level. The top can be kept covered when the water is not running, or the drain pipe can be filled with coarse crushed rock. It is usually unnecessary and undesirable to insert these pipes near the trunk; the best place is out beneath or beyond the ends of the overhead branches, as that is where the feeding roots are located in ordinary round-headed trees. Another and often better way to water the roots under such conditions is to use a crowbar to make holes 18 or 24 inches deep and about the same distance apart throughout and somewhat beyond the region of small feeding roots, or a spading fork can be used with good results to perforate a sod, just before watering.

AIR REQUIREMENTS

Air, more particularly oxygen, is as essential to plant life as it is to human beings, and for the same reasons. The process of breathing (respiration) is the same in both plants and animals, although the structures regulating the processes are different in the two types of organisms. Air must reach every part of a plant, including the root system. It must reach the interior of the plant. In most plants, including trees, it enters the interior through microscopic openings (stomata) mainly in the lower surface of the leaves, and through specially constructed areas of loosely arranged cells (lenticels) in the bark. These openings communicate with tiny labyrinthian air channels through the interior.

Like human beings trees may become sickly or die if the surrounding air (either above or below ground) contains an excess of noxious gases. They may be asphyxiated through inability to obtain oxygen, as is supposed to happen when the breathing areas in the bark are clogged by painting a considerable portion of the healthy bark with air-impervious oil, tar, or paint. Most trees may be suffocated (drowned) by a long-continued superabundance of water in the soil around the roots.

FOOD REQUIREMENTS

In the presence of sunlight and heat the tree manufactures its own food, mainly from water and its impurities taken in by the roots and carbon dioxide from the air. Water from the soil, with small amounts of various inorganic substances in solution, is absorbed by the root hairs and small roots, carried up through the sapwood of the root, trunk, limbs, twigs and through the veins of the leaves to cells containing the green pigment (chlorophyll). Here in the presence of light and heat the transformation from inorganic substances to organic food takes place. Some of the water that reaches the green leaves has its elements separated and recombined with carbon from the carbon dioxide of the air, to form ultimately such organic food substances as sugar and starch.

These newly formed organic foods are carried downward mainly through microscopic conducting tubes and cells in the inner bark to parts of the tree where growth is active. There they may be transformed into new tissues of the roots, twigs, leaves, wood, bark, flowers, fruits, etc., or if an excess is manufactured it may be stored in various forms and at various points for future use. Starch and other newly formed solid foods necessarily have to be changed (digested by ferments) into soluble substances before being carried through the tissues to other portions of the tree.

Whenever a tree shows many dead limbs or twigs or whenever the tree has been treated for a considerable amount of disease or injury, it is advisable, and often essential, that fertilizers be applied to the soil so as to supply raw plant food and to stimulate growth. This is particularly important after extensive cavity work or pruning on the trunk or large limbs, and this treatment usually is very beneficial to all trees that are not in full vigor.

One of the best fertilizers for immediate effect is nitrate of soda, applied broadcast in the spring or early summer at the rate of 2 to 5 pounds for a medium-sized tree. The direct effect of this usually lasts for a year only, but the indirect effect may be apparent the following year. It usually stimulates the healing of wounds made by pruning or cavity work, and also the production of darker foliage. However, an excess, or an application late in the season, may cause injury or excessive development of leaves and failure to properly mature the new wood before winter. Sulphate of ammonia is even better than nitrate of soda except for securing immediate effect early in the spring. It is more slowly available and its effects are more lasting, consequently it is generally safer to use it in the middle of the summer or late in the summer. For oaks, most evergreens, and other trees that naturally thrive on an acid soil, unless the soil is very acid and quick stimulation is imperative, sulphate of ammonia is usually better than nitrate of soda.

A more lasting fertilizer is well-rotted manure worked into the soil at the rate of 10 to 20 cubic feet to 100 square feet of soil. Fertilizers need not be applied near the trunk, although usually they are not without benefit even there. They should be used in a circle just under and beyond the tips of the spreading limbs; say for a tree with limbs reaching 20 feet from the trunk, the fertilizers can be used to the best advantage in a circle ranging from 15 to 30 feet from the trunk. Under some circumstances it may be desirable to mix manure with the soil to a depth of 2 feet or more in a trench beginning at the tips of the spreading branches and running out for 10 or 15 feet beyond the tips of the branches. This general rule for locating the trench applies only to round-headed trees; for spiry trees have the inner edge of the trench about half the height of the tree from the trunk. It is not always possible or advisable to do this trenching in the manner described, but if the trench is placed nearer the trunk than indicated, there is always the danger of injuring the larger roots with the spade or fork if great care is not exercised. In some cases no particular harm appears to have resulted when the ends of the roots up to an inch in diameter were cut off cleanly, as this seemed to stimulate the formation of small feeding roots in the new soil in the trenched area.

A very good, economical method of introducing fertilizers into the soil—a method that does not seriously disfigure a well-kept lawn or a street parking strip—is to make crowbar holes as indicated on page 7 and fill these with the proper chemical or natural fertilizers, nearly to the top. A still better method is to drill holes through the sod to a depth of about 18 inches, insert the fertilizer, and force it through the soil under high air pressure. As this method requires an air compressor, strong air tubes, and a specially constructed patent nozzle, it is not available for the novice. Some tree-surgery firms are equipped with appliances to do this type of work. In restricted areas such as parking strips along streets, treatments may need to be made more or less continuously to supply the needs of the trees in order to compensate for the limited ground space.

Raw bone meal is a good fertilizer for most trees, but is only slowly available. This is often an advantage. It usually stimulates fruit and seed production and does not seem to injure trees when used in considerable quantity. Lime in small quantity is usually beneficial to many trees, but is injurious to many others, especially those that grow naturally or preferably in an acid soil, for example, most oaks and pines, and black and red spruce, but not the white spruce.

A few excellent fertilizers containing stable or sheep manure, bone meal, and other necessary ingredients are on the market. As it is not easy for the novice to determine just what essential elements (if any) are lacking in the soil it will be simpler for him to use a fertilizer containing nitrogen, phosphorus, and potash, even though one or another may not really be needed.

CAUSES OF INJURY

PAVEMENTS AND OTHER URBAN CONDITIONS

Probably pavements directly or indirectly cause the ill health or death of more trees along city streets than any other one factor. Impervious pavements prevent rain water and air from entering the soil. Gas from leaky pipes or even gas from the tar or asphalt pavements cannot readily escape. Any or all of these conditions may cause ill health or death. Exhaust gases from automobile and other gas engines are known to be injurious or even fatal to human beings and animals, and there is evidence to indicate that such gases may be injurious to plant life also. The fumes and dust from oiled or tarred roads, fumes from smelter and chemical works, dust from cement works, and smoke are known to cause injury to nearly all forms of plant life with which they come in contact, if they are present in sufficient quantity.

Trees and shrubs often are scorched, burned, or otherwise injured by being located where whitewashed or light-colored walls reflect the heat of the sun. Too-dense shade, too-intense sunlight, or too-close planting is often responsible for certain types of injury.

Ice, snow, or wind may break limbs or uproot trees, which in turn may injure other trees as they fall. Horses frequently gnaw the bark of unprotected street trees. Telephone, telegraph, and electric linemen with their climbing spurs and saws are notorious mutilators of shade trees in towns where the trimming of trees is not regulated by law. Electric wires carrying a high voltage may discharge heavy currents through trees if the insulation becomes defective. Wheels of horse-drawn vehicles and automobiles frequently wound or tear away large pieces of bark.

LAWNS

Many ornamental trees are located in lawns or grass plots, locations that are not ideal for their best development. However, many trees appear to remain healthy under such conditions, and most of them will do so if the supply of water and food is sufficient at all times for both tree and grass. If the supply of water for any extended period (sometimes for a period less than a month) is insufficient for both tree and grass, the former will generally suffer more permanent injury than the grass, unless there is some source of water supply in the subsoil. Particularly is this the case during dry seasons when the only available supply of water comes in the form of occasional light showers or artificial watering. Under these conditions the grass may take up practically all the water that falls and the tree continue to experience drought conditions. A short heavy rainfall, especially on sloping ground, seldom penetrates to the roots of the tree, as the sod appropriates the small amount that does not run off.

Perforating the sod with a manure fork or crowbar just before a rainfall or routine watering will greatly facilitate the passage of water into the soil beneath the sod. Under certain conditions of sod this may be the only practical way of readily wetting the roots of the tree without breaking up the lawn. However, there is great danger of injuring the roots with the fork or crowbar if it is used near the trunk or over large roots. The proper place to perforate the sod is out near and beyond the tips of the spreading overhead branches.

What has been said regarding the application of water to a grass sod applies equally well to fertilizers when applied broadcast. Owing to the fact that a dense mat of grass roots is nearer the surface than the tree roots the grass will be benefited by the application, while the tree roots may receive practically none. If fertilizers are intended primarily for the tree they should be placed beneath the sod by means of crowbar holes, as described on page 7, or, better for the tree, if circumstances warrant such extreme measures, the sod broken up, the fertilizer applied, and the ground left fallow for at least part of a year, and later resodded or reseeded. Measures of this kind must sometimes be used to save or improve the growth of street trees that grow under adverse conditions at best. The growth of annual crops or flowering plants beneath trees is usually beneficial insofar as it keeps the soil loosened and aerated and precludes the growth of grass sod; while the yearly application of fertilizers to the garden enriches the soil and, if manure is used, conserves its moisture. On most lawns it is customary to mow the grass and immediately rake up the clippings. If these clippings were allowed to remain they would serve as a thin mulch, and as they decayed the soil would be still further enriched. The practice of removing the clippings materially contributes to the impoverishment of the soil.

INSECTS

It is a matter of common knowledge that insects cause in many different ways an enormous amount of damage to trees. They also cause indirect damage to trees by acting as carriers for such diseases as the Dutch elm disease. However, as insect injuries to trees lie within the province of the entomologist, they will be considered in this bulletin only in a general way when they are associated with fungi in producing decayed areas in tree trunks and limbs. Readers who are specially interested in insects and insect injuries and methods of control are referred to the publications of the Bureau of Entomology of the United States Department of Agriculture and of the various State entomologists.

Damage done by such birds as woodpeckers in plugging holes in trees to extract insects lodged in or under the bark is discussed in publications of the Bureau of Biological Survey of the United States Department of Agriculture.

RODENTS

Rodents, such as field mice, pocket gophers, rabbits, and porcupines, may injure fruit and other trees. Information on these animals has been published by the Bureau of Biological Survey. Rodent injuries should receive treatment similar to that of other injuries. But in case of complete girdling of young and vigorous trees bridge grafting[1] may be used if the value of the tree justifies the expense.

FUNGI

Fungi are low types of plants, which produce no true flowers or seeds. They lack the green color pigment of ordinary green plants, and in consequence cannot manufacture their own food from the inorganic elements. However, in order to live and grow they require food just the same as all other plants and all animals. Because they cannot manufacture organic food they have to obtain it in other ways, by appropriating food that has already been manufactured by some green plant. When a fungus obtains its food from a living organism it is known as a parasitic fungus or a parasite; when from dead organisms it is known as a saprophytic fungus or a saprophyte. Fungi, like other plants, have a vegetative or growing stage and a fruiting or reproductive stage. In ordinary green plants the roots, stems, and leaves represent the vegetative stage, and the familiar flowers and fruits represent the fruiting stage. In fungi the vegetative stage is composed of microscopic threads (hyphae) which grow in or on living plants or animals, or in or on dead and decaying plant or animal matter, from which they absorb the necessary organic "ready-made" food. The vegetative mass of threads is known as the mycelium and in bulk may be visible to the naked eye, as, for example, the familiar cottony mold on fruits. However, this stage of a parasitic fungus usually is not seen by the ordinary observer because it commonly occurs only within the tissues of the living plant or animal (known as the host) from which it obtains its food.

The fruiting stage of a fungus is more familiar to the layman than is the vegetative. Mushrooms, toadstools, puffballs, etc., represent the fruiting stages of certain fungi. Most fruiting bodies of this particular sort occur on leaf mold, dead logs, or other decaying organic matter, but certain species occur on living trees. Fungus fruiting bodies occur in a great variety of other forms, colors, and sizes. At maturity each of these fruiting bodies commonly produces innumerable microscopic reproductive bodies (spores), each of which may produce a new fungus plant under favorable conditions. The dustlike cloud which arises from a mature puffball when it is tapped is composed almost entirely of such spores. It is obvious from what has been said that the prompt destruction of young fruiting bodies before they mature their spores is of vital importance in preventing the spread of the fungus, just as the destruction of the annual weeds

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[1] Farmers' Bulletin 1369, Bridge grafting.

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before they mature their seeds is one of the most important factors in their extermination.

Other facts concerning fungi that should be kept in mind in connection with the treatment of tree wounds are: (1) A fungus rarely produces a fruiting body until it has a well-developed vegetative stage to supply it with food; consequently when a fungus fruiting body appears on a tree (or elsewhere) it means that a well-developed vegetative stage has existed for some time and is still present. Although it may not be seen by the naked eye unless massed, its hyphae are, nevertheless, growing through the tissues of the host. (2) Usually a mere fragment of a single hypha remaining in the wood will continue the fungus vegetatively. (3) The area of active growth of the vegetative stage of the fungus can sometimes (but not always) be known by its effect on the wood or bark. This often is discolored, waterlogged, sunken, swollen, decayed, or hollow. (4) All of this vegetative stage must be removed or killed in order to stop further possible decay or disease. (5) If a fungus fruiting body is left on the tree the disease may be spread readily to other trees or to other parts of the same tree. Also it means that there is a considerable portion of the vegetative stage still growing in the tree and capable of increasing the area of the disease after the fruiting body is removed.

Fungi cause many diseases of trees, but, what is of more immediate importance in connection with injured trees, they also cause decay of the wood, particularly in the immediate vicinity of wounds. If unchecked this decay may eventually so weaken the tree that it will break in a heavy wind. Failure to properly treat freshly made wounds causes needless expense in later years if attempts are then made to counteract the ravages of fungi causing the decay. Organisms of decay work mainly in the woody portions of a tree, gaining entrance through injuries and neglected wounds of various sorts and extending up and down the interior of the trunk, often for long distances. They usually continue their work of decay indefinitely or at least until the infected areas are properly cared for as indicated on page 24. Hollows or diseased spots in trees arising from external injuries are familiar sights. In most cases they have been caused by fungi that were allowed to grow for years with little or no attempt being made to check their ravages. Trees along streets and highways need regular inspection for such conditions to prevent their becoming hazards to traffic.

MISTLETOE

In the Southern and Pacific States mistletoe is a common pest of many shade trees, producing on the tree branches globular masses from a few inches to several feet in diameter. Mistletoes are parasitic flowering plants that obtain their food by sending rootlike "sinkers" into the tissues of the tree and sucking up food that has already been manufactured by the green portions of the tree. If mistletoe is in great abundance it is a distinct menace to the host tree and in extreme cases may kill it. The complete eradication of mistletoe involves killing the "sinkers" or removing them by pruning. However, mistletoe usually can be kept under control by breaking off the brittle growths every year or two with a long pole or other suitable implement.

PREVENTION BETTER THAN CURE

Preventing the formation of a pocket of decay or preventing a disease from getting started on a tree is far better and much more economical than trying to cure either in later years.

If trees are located along driveways or streets, or in other situations where horses can easily reach them, they should be protected by tree guards. If a limb is so located that it crowds or rubs another, one of them usually should be removed. Cut out the one that is least essential to the tree, from whatever standpoint is considered most important, such as size, vigor, location, symmetry, etc.

Although the remaining pages of this bulletin are concerned mainly with pruning and cavity work, the significant fact should always be borne in mind that proper feeding and watering of diseased, decayed, or otherwise weakened trees often are of much greater importance. It usually is an excellent rule to feed all trees that have been subjected to much pruning or cavity work, in order to stimulate prompt callus formation over the edges of all wounds, and it is quite essential to do so in the case of weakened trees.

If injuries remain untreated, decay may penetrate into the interior of the tree and increase from year to year until large limbs, or the trunk itself, become so weakened that they break in a violent wind. It requires comparatively little time and money to clean and paint a freshly made injury. It often requres much time and money to treat properly the same injury after it has been neglected for a few years. Moreover, an injury promptly treated will heal and cover the scar more quickly and effectively. Almost every large decayed area has resulted from an injury that would have required comparatively little time and effort to clean, sterilize, and dress at the time it occurred. The most economical and effective method of preventing a decayed area in a tree is to attend to the injury that may eventually give rise to it as soon as the injury occurs, perhaps 20 or 30 years before it would become a real menace to the tree. This fact should be remembered by tree owners and persons charged with the care of trees. If acted upon, it may mean an ultimate saving in later years of many hundred percent in the cost of keeping the trees in good condition.

Practically all cavities might have been prevented if the original injury had been properly treated as soon as it occurred, so that the healing tissues could have grown over the sterilized and protected wound. Because this has not been done to any extent in the past, a demand has been created for tree-surgery methods—methods which often cost today, through past neglect, many times the amount that it would have cost to forestall the decay 10 or 20 years earlier. Moreover, an injury promptly treated might today be entirely or relatively inconspicuous. Neglect for 10 or more years means that the decayed area will be conspicuous and unsightly for years to come, if not during the entire remaining life of the tree.

WHAT TREES ARE WORTH TREATING

Most shade and ornamental trees with only a few dead limbs are unquestionably worth attention. Others that have many dead limbs or decayed areas may not be worth the expense, particularly if they are rapid-growing short-lived trees. This point should be considered very carefully before any work is undertaken. Under no circumstances should a badly diseased or insect-infested tree be allowed to remain as a menace to nearby trees that are in a more healthy or entirely healthy condition. All diseased or insect-infested bark, wood, or leaves should be removed and all freshly cut surfaces properly treated, or the entire tree should be removed. In most cases the diseased portions should be burned immediately; in case of doubt as to the contagious character of the diseased portions, it is better to err on the safe side and burn them. No one can decide better than the owner whether a tree is worth the expense of trying to save it, because the actual commercial value of an ornamental or shade tree usually has nothing to do with the decision. It is generally a question of esthetic value, or historic associations, or rarity of species, or location for shade. A man who has had experience in caring for mutilated or diseased trees may be able to say definitely whether it is possible to prolong the life of the tree, but the owner, who has to do the work or pay the bill, is the one who will have to decide whether the tree is worth the expense of treatment. Often the owner will be better satisfied in the end to have a badly diseased or mutilated tree replaced by a healthy, perfect one. In expert hands the moving of comparatively large trees is no longer a hazardous undertaking, although it may be expensive.

WHEN THE WORK MAY BE DONE

Tree work has heretofore been undertaken at almost any time of the year when the sap has not been running too actively and the weather has not been too cold. In view of the fact that the plugging of the tubes in the water-conducting tissues by means of organic gums takes place primarily only during the actively growing season, it is quite likely that experience and authentic records later will show that the best time for major pruning and cavity work will be during May, June, July, and August, and the next best time in September and October, for the Northern States; and for a somewhat more extended period in the Southern States. Extensive cutting of trees should be avoided during the "bleeding" season. In most trees this will mean only during the time the buds and leaves are expanding in the spring. Freezing weather may injure cement work before it is fully set. Fillings composed largely of tar or asphalt are harder to handle in cold weather. These facts may have some bearing on the time selected for doing the work. They are important in making up schedules for maintenance and operating crews on public and semipublic projects.

TREATMENT

THE MOST IMPORTANT OPERATIONS

In the following pages will be found directions for treating injured trees, and portions that are decayed or diseased. Several different methods usually are described so that a choice can be made, dependent upon circumstances or necessity.

By far the most important operation is to treat all injuries as soon as possible. All splintered or loose wood and bark should be removed with a sharp cutting instrument and the cut edges shellacked, and, a day or two later, the whole wound properly dressed, as described below.

When a wound has developed an area of decay, all of this should be removed and the cavity treated the same as any freshly made wound.

If decay has progressed for some years it may be impossible to remove all of the fungus causing it without so weakening the tree that it will be a menace to life and property. This is one of the penalties of not attending to injuries as soon as they occur. If all the decayed tissues are not removed the fungus may continue its work of destruction.

In treating tree wounds a few fundamental principles must be observed, in order to secure permanently good results. These may be summarized briefly as follows:

(1) Remove all decayed, diseased, or injured wood or bark. When it is on a limb this can often be done best by removing the entire limb; if it is on a large limb or on the trunk it may be necessary to cut out the decayed matter, leaving a cavity.

(2) Sterilize all cut surfaces. This may be omitted if a good sterilizing dressing is used. (See item 3.)

(3) Protect all cut surfaces from external moisture and other injurious external agencies by also applying a more permanent dressing over the sterilized surface.

(4) Leave the work in the most favorable condition for rapid healing; this may sometimes necessitate filling deep cavities.

(5) Watch the work from year to year for defects, and if any appear, repair them immediately.

The simplest type of work consists in removing dead or dying limbs or neglected or decayed stubs and in treating the wounds so as to prevent the entrance of decay-producing organisms and moisture while the healing is taking place. A more complicated type consists in digging out decayed and diseased wood and treating the freshly cut surfaces of the cavities as described later (p. 24), and sometimes in filling the cavities with suitable material. The artificial filling of an ordinary cavity does not usually increase the strength of the trunk or limb. An improperly filled cavity is probably always a menace to a tree.

SOME THINGS TO BE AVOIDED

The careless use of a long pruning hook or other implement to break off small dead twigs should be avoided, as every bruise may become the point of entrance of disease or decay. Climbing spurs produce wounds that are very easily and frequently infected. Spurs should never be used except on a tree that is soon to be removed or destroyed. A man who insists on using climbing spurs in tree-repair work should never be allowed to work on trees. Nails and hard leather soles and heels on shoes often cause injury. Rubber-soled tennis shoes, or "sneakers", or some similar soft-soled shoes that will not slip should be worn when it becomes necessary to climb a tree.

Limbs or trees should never be guyed by passing wires, chains, or ropes tightly around them. These may eventually strangle the portions above the encircling band. Encircling fence wires, telegraph wires, or clotheslines may act in the same way, killing all parts of the tree beyond the ligature if they remain tightly drawn around the limb or trunk for any great length of time, often in less than a year.

GUYING AND BRACING

Closely associated with tree-repair work, and often really a part of it, is the guying and bracing of limbs to prevent the splitting of the crotches or to check splitting that has already started.

A simple method of bracing a crotch is to put a hook or eyebolt through each limb, with the hooks or eyes toward each other and from 3 to 10 feet or more above the crotch (depending upon the size, position, and length of the limbs), and to tie these hooks by means of a strong wire, wire cable with thimble and clips at the ends, or chain (figs. 2 and 3). Three or more adjoining limbs may be guyed collectively. The precautions mentioned on page 28 should always be followed, so far as they apply to boring and tarring the hole and countersinking the washers of the bolts. On smaller limbs heavy coarsely threaded screw hooks or screw eyes can be substituted for the bolts.

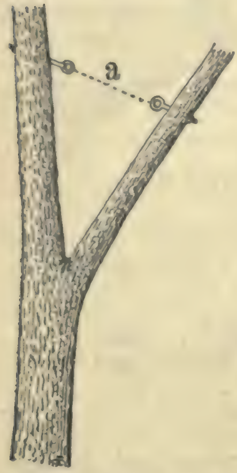

FIGURE 2.—Side view of limbs, showing the proper method of guying them above a weak or split crotch. The wire, cable, or chain guy is shown at *a*.

A turnbuckle in the rod, bolt, cable, or wire guy will be of use in keeping it taut at all times, as this permits a ready tightening of the guy within certain limits, should it later become advisable to do so. If a very taut guy is desired one end of a heavy wire (e.g., a telegraph wire) can be securely fastened to one eyebolt, looped through the second eyebolt, drawn up as tightly as convenient, and the free end securely fastened at the first eyebolt, leaving a guy composed of two wires. An iron bar placed between the wires can then be used to twist them as much as desired, thus shortening the guy and drawing the two limbs more closely together. This simple device can often replace a turnbuckle guy. If for any reason the guy is to be placed within a foot or two of the crotch, a single long bolt or screw rod can often be used to better advantage, and sometimes a single long bolt or screw rod with a swivel can be used in place of a cable, a chain, or a turnbuckle rod where the guyed limbs are not likely to twist much as they sway in the wind. If one or more bolts are to be used through, or above, a split crotch, follow the detailed directions given on page 27. More complicated types of bracing may well be left to a reliable commercial tree surgeon who is specially trained for this sort of technic.

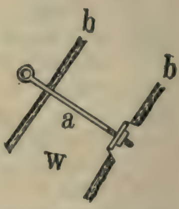

FIGURE 3.—Sectional view of the limb in figure 2, showing the details of placing an eyebolt of the type shown in figure 2: *a*, Bolt; *b*, bark; *w*, wood.

Occasionally it may become necessary to guy a whole tree in order to prevent the breaking of the trunk when an unusually large cavity leaves only a thin shell of sound wood, or to prevent a tree that has recently been set from tipping over before its roots have become well established. This can be accomplished by attaching four guy wires or ropes to the tree about half way from the ground to the top of the tree and having these slant downward at an angle of about 45° to four stout posts set firmly in the ground about equidistant around the tree (e.g., on the north, east, south, and west sides of the tree). If the guying is for temporary purposes only, two broad bands of leather or stout canvas or other strong material, each long enough to make a loop at least twice the diameter of the trunk or limb to be encircled and 4 to 6 inches wide, may be passed around the tree or some favorably situated limb and two adjoining guys attached to each loose loop. If a permanent guying is needed, two eyebolts (or hookbolts) can be placed through parallel creosoted holes in the trunk or limb about halfway up the tree, one 6 inches or more above the other. The eye of one bolt should be on the opposite side of the tree from the other. Two guys from two adjoining posts are attached to each eyebolt, the latter pointing halfway between the two posts to which the guys are to be attached (fig. 4). The chafing of a limb against a guy should be prevented by padding the guy wire with a piece of garden hose or the limb with burlap, provided the guy cannot be so placed or braced as to clear all limbs. A piece of an old automobile tire may often be used effectively.

REMOVING BRANCHES

The removal of healthy, broken, dead, or diseased branches when the cut is made entirely through healthy wood comprises two essential operations: (1) Removing the branches in a manner that will prevent injury to the surrounding bark and cambium and leave the wound in the most favorable condition for prompt healing; and (2) sterilizing, shellacking, or otherwise protecting the scars against infection. If decay runs back into the trunk, a third step is necessary. All decayed matter should be excavated, following the directions given under Cavity Work (p. 24).

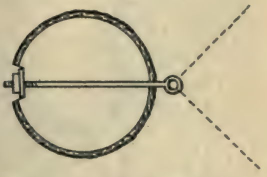

FIGURE 4.—Sectional view of a tree trunk, showing the details of placing bolts for permanently guying a tree to the ground. This method of placing a bolt is used also in guying three or more limbs together. The broken lines indicate the guy wires.

The most useful implements for removing large branches are a good-sized saw with teeth so set as to make a wide cut, a gouge, a chisel, a mallet, and a strong sharp knife. An oilstone is needed for sharpening the tools. For cutting limbs near the ground, these are the only necessary implements, although others may often be convenient.

For work higher up in the tree ladders or ropes may be needed. If the work is to be done from the ladder, the top should be securely tied or otherwise fastened to the tree so it cannot slip. Most tree workers have practically abandoned the use of ladders except to get up to the lowest branch of the tree, ropes being thrown over limbs higher up, both for assistance in climbing and for support for the workman below, or to enable him to swing from one portion of the tree to another. A light one-pole scaling ladder similar to that used by firemen will sometimes be handier than the ordinary heavier two-pole ladder. This can be hooked over limbs at different heights and used to facilitate fastening the ropes. If a scaling ladder is used, the hook should be well padded with some soft material to prevent its bruising the bark. If the workman wears a heavy belt with a strong snap hook attached to it, similar to that used by electric linemen when working on a high pole, and has this hook snapped into a loop at the lower end of a rope securely attached to an overhead branch, a fall may be prevented.

After a severe ice or wind storm all broken and hanging branches that are a menace to life or property should be removed promptly, generally by being cut at the break. A general survey of the condition of the tree should then be made in order to learn whether injuries are too numerous or extensive to warrant attempting to save it. If an attempt to save the tree seems warranted, and the tree is badly smashed, some or all of the main stubs (after the splintered ends have been trimmed off) may be left until growth starts sufficiently to show where vigorous buds or shoots will develop. The ends of the stubs may then be removed with a slanting cut starting just above a vigorous bud or shoot and running back and across the limb at an angle of about 45°, and the scar properly treated. The developing bud or shoot must be at the peak of the slanting cut.

A large limb should rarely be removed by a single saw cut from the upper side, as this usually strips the bark and wood below the scar as it falls (fig. 5). A preliminary cut should be made on the under side, usually from 6 inches to a foot beyond the point where the final cut is to be made. It should reach from a quarter to half way through the limb (fig. 6, *a*). A good time to stop is when the saw becomes pinched in the cut. A second cut should be made on the upper side of the limb, an inch or more beyond the first one (fig. 6, *b*) and continued until the limb falls. A third cut, to remove the stub, should then be made close to the trunk (fig. 7, *c*). When nearly severed the stub must be supported so as to avoid any possibility of stripping the bark on the trunk as it falls. The first and second cuts may be omitted when a limb is so small that it can be held firmly in place until completely severed. If desired, the edges of the scar may be smoothed with a sharp chisel to conform to the trunk. A flat cut of the type described will usually heal over with a depressed place in the center. This is sometimes objectionable. In attempting to counteract this tendency some tree workers leave a slightly conical or convex scar, the center being an inch or more higher than the margin for a scar 6 inches in diameter, and proportionally higher in larger scars. All final cuts should be made so as to allow rain water to drain off readily.

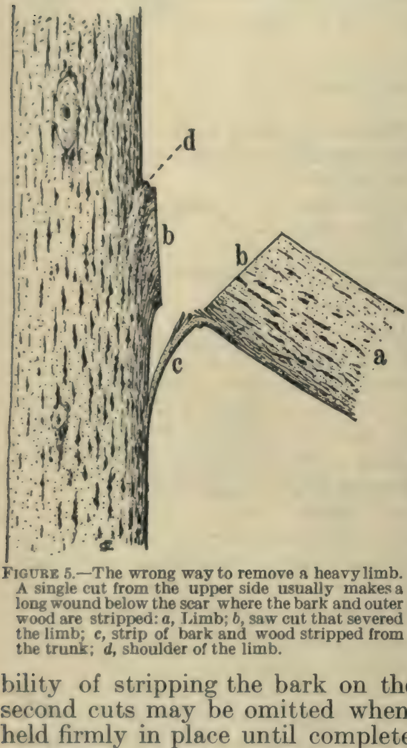

FIGURE 5.—The wrong way to remove a heavy limb. A single cut from the upper side usually makes a long wound below the scar where the bark and outer wood are stripped: *a*, Limb; *b*, saw cut that severed the limb; *c*, strip of bark and wood stripped from the trunk; *d*, shoulder of the limb.

A large limb often can be removed safely with a single downward saw cut close to the trunk if handled as shown in figure 8. The object of the rope or prop is to lift the base of the limb as it falls, thus causing the splinter of bark and wood to be stripped from the branch instead of the trunk. This splinter attached to the trunk is then sawed off. It is bad practice, as well as a menace to the tree, to leave a projecting leafless stub (fig. 9) as such a stub will almost always die back close to the trunk or supporting limb and into the heartwood if left untreated. The scar should be pointed at both ends (fig. 10), as this is the most favorable shape for satisfactory healing. If the cut has not been made through perfectly healthy wood, the wound should be cut back until sound healthy wood is reached.

A good coat of shellac varnish [2] should be applied with a suitable brush over the entire cut edge of the bark, the adjoining outer sapwood, and the cambium, immediately after the cut is made, or at least as soon as the cut surfaces are sufficiently dry to allow the shellac to stick securely to the wood. This is to prevent any appreciable drying out and consequent dying back of the cambium. Shellac is merely a temporary dressing, although it is a very important step in the repair process (p. 14). Usually it is unnecessary to shellac more than half an inch on either side of the cambium. If the scar is a large one, a sharp knife or drawshave should be used along the margin for 1 or 2 minutes, and then the freshly cut surfaces shellacked, the operation being repeated until all the bark and outer sapwood encircling the scar have been shellacked. The maximum benefit from shellacking is not likely to be realized if the freshly cut surface is allowed to remain dry and without shellac for more than 3 or 4 minutes. The shellac brush can be cleaned readily at any time by working it around for a few minutes in a can of water in which a little borax has been dissolved. It is then rinsed in clear water and dried before being used again. The shellac can be conserved while in use by having the handle of the brush fitted tightly through a hole in the cover of a friction-top can, and leaving the cover on the brush when it is used to spread the shellac.

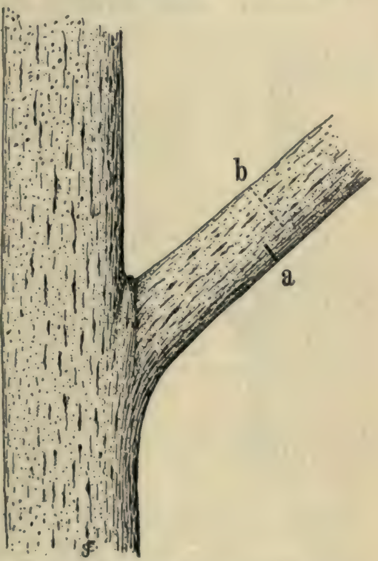

FIGURE 6.—The right way to remove a heavy limb. The first cut is made on the under side of the limb at *a*. The second cut is made at *b*, and is continued until the limb falls.

A mixture of 4 parts asphaltum and 1 part of paraffin applied warm is used in place of shellac to protect the freshly cut cambium in some western orchards and is highly recommended for that purpose by those who have used it.

For the work of removing small branches, either a saw, a sharp strong knife, a hand pruner, a chisel, or a long pruning hook may be used, as seems most suitable. In skillful hands a small sharp hand ax may be used to greater advantage. In removing small branches and twigs the cut should be made as close to the surface of the supporting branch as possible, so as to leave no projecting stub (fig. 9). A sharp knife, used in an upward cut, is the best tool for the work and should be employed, when possible, in preference to the hand pruner or pruning hook. When the hand pruner is used the cutting blade should always be turned toward the tree, so that the supporting bar makes its bruise on the part that is cut away. The long pruning hook should be used with caution, and only when the place to be pruned cannot be reached with the knife or hand pruner.

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[2] The shellac varnish should be made up in accordance with Federal Specifications Board specification no. 376. In brief, this is, stick lac "cut" in 95-percent specially denatured alcohol, formula no. 1 of the U.S. Internal Revenue Bureau (i.e., 100 parts ethyl alcohol and 5 parts approved wood alcohol).

For protection against possible infection, the pruning wounds must be treated in much the same manner as recommended above for those on larger branches. For covering the very small wounds no more permanent covering than shellac may be needed. Liquid grafting wax is particularly satisfactory for scars less than a half inch in width on choice trees or shrubs, or on scars that are susceptible to injury from the use of tar or creosote. In resinous trees the exuding resin, if well smeared over the cut, will usually give ample protection against the entrance of decay-producing organisms.

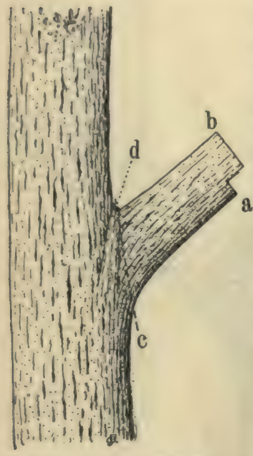

FIGURE 7.—The right way to remove a heavy limb. The third cut is made close to the trunk so as to leave no projecting stub. Both *a* and *b* are the same as in figure 6; *c* indicates the position of the third cut; the shoulder of the limb is shown at *d*.

The statement has often been made, and very widely accepted, that it is unnecessary to paint the scars made by cutting small branches a half inch or less in diameter; but the writer has observed many instances in which serious diseases have gained entrance through wounds that were considerably less than half an inch across. For thorough and careful work, particularly on choice trees or shrubs, the smaller scars should be as thoroughly treated as the larger ones. Care should be taken, however, that waterproof and airproof coverings are not applied to the surface of the uninjured bark adjoining the wound, or injury may result. Small untreated scars near the tips of small branches are not ordinarily a source of great danger, for if infection takes place it usually is possible to cut off the small limb farther back without seriously disfiguring the tree.

It sometimes is desirable to alter the shape or to reduce the size of the crown by pruning. When the trunk, or a crotch, is much weakened by decayed heartwood, or by much cavity work, it often is necessary to prune back heavily all the main branches, so as to materially reduce the size and weight of the crown. By so doing its weight is reduced, but what is of even greater importance, there are no long limbs left to exert their tremendous strain on weakened trunk or crotches when the wind blows. Trees pruned in this manner usually produce a smaller, well-rounded, and compact head in a comparatively few years. This type of pruning is common in Europe and in the drier regions of our own Southwest, but rarer in the eastern part of the United States, although it has been used with excellent results in the Arnold Arboretum. Under certain conditions, notably when the trunk is small, hollow, or otherwise weakened, it is the only type of pruning that should be considered. Street and roadside trees should be pruned in such a way as to preserve their general normal outline as nearly as possible. Pruning also is commonly employed on fruit trees to stimulate fruit production.[3]

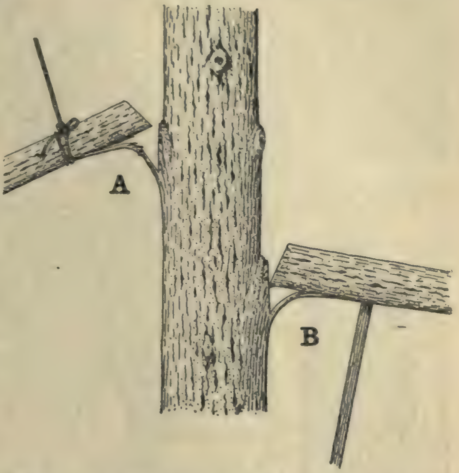

FIGURE 8.—A heavy limb can often be removed safely with a single downward saw cut if the limb is supported with a tightly drawn rope, as shown at *A*, or by a firmly placed heavy prop, as shown at *B*. This causes the end to lift as the limb falls. Both rope and prop should, if possible, be so slanted as to cause the limb to swing away from the trunk as it is severed. If the rope is tied to a living overhead branch, the latter should be well padded to prevent injury.

STERILIZING AND DRESSING WOUNDS

The ideal dressing for a wound is yet to be discovered. Many antiseptic and sterilizing preparations have been used with more or less success, but no dressing known has proved reasonably efficient unless the work has been carefully followed up from year to year and defects that appeared promptly repaired. Ordinary commercial creosote (a coal-tar product, sometimes called creosote oil) apparently is one of the best preparations for destroying and preventing the growth of wood-destroying fungi. It can be applied to a tree wound with an ordinary paintbrush and should cover every part of the exposed wood that has not already been covered by the shellac. The entire shellacked and creosoted surface may then be painted with thick coal tar or asphalt. For applying clear hot asphalt use a cloth swab or a brush made of broomcorn, as the bristles of an ordinary brush usually are soon destroyed if the asphalt is very hot.

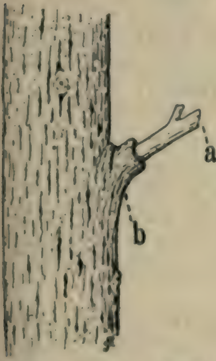

FIGURE 9.—A projecting stub of decaying wood which has become a menace to the living parts adjoining. This limb was cut at the point marked *a*; it should have been cut at *b*.

A single application of a mixture of creosote and coal tar (about one fourth or one third creosote) to cover the entire scar has been extensively used with good results. A better dressing is made by mixing melted asphalt with an equal quantity (by weight) of creosote. *As creosote is inflammable, care should be taken that it does not come in contact with an open flame.* A good way to mix the two ingredients is to melt the asphalt, then remove it from the heater and thoroughly stir in the necessary amount of creosote. If the mixture is too thick to apply when cold, reheat it and stir in more creosote. Asphalt without creosote (p. 31) is one of the best coverings and doubtless would be more generally used were it not necessary to apply it hot. A prepared

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[3] See Farmers' Bulletin 181, Pruning.

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emulsion of asphalt and water can be obtained in the open market. This preparation is excellent for wounds and can be applied in the same way as ordinary paint. It does away with the necessity of heating the preparation and after a few hours the water largely evaporates and leaves a coating of practically pure asphalt. The brush used to apply it soon becomes stiff, unless kept in water when not in use. Instead of a brush, a cheap, easily made swab can be used and may be discarded later. Paint alone frequently is used for a dressing but is less effective.

The creosote and tar mixture at times will cause injury when used around wounds on certain trees, especially cherries, peaches, and plums. Except on magnolias and tuliptrees, such injury has not been especially noticeable on most of our common shade trees. If injury from the use of this dressing is feared, a moderately blue solution of copper sulphate in water, or 1 part of corrosive sublimate in 1,000 parts of water, may be used as an antiseptic wash. The copper-sulphate solution is composed of 1 pound of copper sulphate (bluestone or blue vitriol) in 3 or 4 gallons of water. *Corrosive sublimate (or bichloride of mercury) is a deadly poison to man or animals if taken internally and is a caustic or corrosive agent on the skin or on metals.* The 1 to 1,000 solution can be made most readily by purchasing the 7- or 7.3-grain tablets of bichloride of mercury at a drug store, where they are sold subject to laws governing the sale of poisons. One of these tablets dissolved in a pint of water will make a solution of the proper strength. The solution should be freshly mixed for the best results. Usually it will retain sufficient strength for ordinary use for 2 or 3 months. If placed in an amber or blue bottle away from the light, it will keep at least 2 or 3 times longer. As a precautionary measure against the accidental poisoning of domestic animals, the discarded solution should be buried rather than poured into a sink drain or thrown out on the surface of the ground. Solutions should not be kept in metal containers, nor should brushes with metal coverings or wire-fastened bristles be used for applying it, as the solution promptly corrodes all metals with which it comes in contact. As soon as the antiseptic wash is dry the wound can be painted with any good lead paint, or even spar varnish. Grafting wax (particularly thick liquid alcoholic grafting wax) is excellent for treating small surfaces.

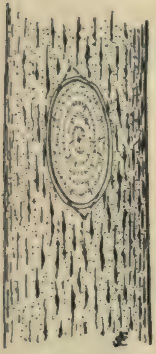

FIGURE 10.—If the shoulder has been removed and the upper and lower ends of the scar are broadly rounded or square they should be pointed, as indicated by the broken lines. If the shoulder (figs. 5, *d* and 7, *d*) has not been removed the pointing of the scar is not so important, and at times it is unnecessary.

Some tree workers treat large scars by charring the surface with a gasoline or alcohol blast torch and then quickly covering the hot surface with heavy tar, pitch, or hot asphalt. Heat is an excellent sterilizing agent, but it kills back the cambium considerably. Healthy trees that have wounds caused by very recent fires usually require no further sterilization. A good treatment for such trees is to scrape off most (but not all) of the charred wood and dress the wound as indicated in this section.

On particularly choice trees, where the black color of tar or asphalt is objectionable, the scar can be sterilized with the corrosive sublimate or copper sulphate solution and, as soon as dry, shellacked. When the shellac has hardened it can be covered with spar varnish. For many purposes and on many trees this treatment is particularly satisfactory. If the scar is clean and healthy and not located near any former area of decay or disease, the sterilizing washes may be omitted and the shellac applied directly to the unsterilized scar. The alcohol in the shellac is a good sterilizing agent. If it is desirable that the scar be colored to match the bark, a suitably colored coat of paint can be applied over the shellac and allowed to dry before the coat of spar varnish is applied, or the spar varnish may be omitted.

In some western orchards good commercial bordeaux paste, mixed with sufficient water to allow it to be handled like thick paint, has been quite extensively used with good results but is recommended for temporary purposes only by those who have used it. Apparently it has the advantage of being air-porous but the disadvantage of weathering away rapidly. Moreover, it is poisonous if taken internally and consequently might be a source of danger if used where children or domestic animals could easily reach it. Another preparation still more highly recommended for use in western orchards is a thoroughly stirred mixture of bordeaux powder and raw linseed oil in proper proportion to make a thick paint. Ordinary commercial water glass (sodium silicate), in the proportion of 3 parts of water glass to 1 of water, is another preparation that is being used, particularly in the Middle States, as a wound covering. Although at present it gives some promise of becoming useful under certain conditions, the extent of its usefulness and its limitations apparently have not yet been satisfactorily demonstrated. Both bordeaux mixtures and the water glass are mentioned here merely as promising possibilities which need further testing to prove their worth for shade-tree work.

Permanently good results can be assured only when the dressed surfaces are watched from year to year and recoated annually or biennially, especially when any tendency of the coating to blister, crack, check, or peel is observed. This is a very important part of the work, a part that is commonly neglected. It is best to recoat the wounds regularly every year, even though no cracks or blisters appear. Blistered or loose portions of dressings should always be removed just before repainting.

Weather checks or cracks appearing in the wound must be treated immediately, in order to prevent possible reinfection. If these cracks have been neglected for a time and are sufficiently wide (one sixteenth of an inch or more) to permit them to be sprayed or washed with a sterilizing fluid, this should be done, and the surface repainted. If the cracks are too wide for the new dressing to bridge easily, they may be filled with sawdust and tar, or even with cotton dipped in tar or creosote, which is pushed into the crack with the point of a trowel or putty knife before the wound is redressed.

The healing of wounds by means of new callus growth at the sides is often more rapid if neither paint nor other generally used waterproof covering is applied (shellac excepted). However, the rapid healing of a wound is of secondary importance to preventing the entrance of decay-producing organisms. To prevent, check, or remove decay is one of the most important and essential considerations in the treatment of injured trees. It is of vital importance in the case of long-lived trees. With short-lived trees it obviously is of relatively less importance.

One of the best (though little-used) methods of counteracting the danger arising from cracks in large flat scars, particularly scars that are sound and healthy, is to cover the freshly dressed wood of the wound with heavy tarred paper, or, better, heavy cloth, firmly tacked to the wood and painted. The cloth should be cut slightly smaller than the scar, so as to leave about one eighth of an inch between the edge of the cloth and the cambium. This edge should be firmly tacked down in a manner that will make it impossible for the growing callus to push underneath the edge and lift the cloth. In resinous trees the exuding resin usually makes a good and sufficient dressing to smear over the wound before the cloth is applied.

CAVITY WORK

Cavity work in a tree involves cutting out decayed wood. As already stated, it often is impossible to get all the decayed matter out without so weakening the tree that it may become a menace to life and property, unless the crown is materially reduced by pruning. Many private and commercial workers recommend filling the cavity. A filled cavity that was not properly cleaned and dressed before being filled is of doubtful value. A filling serves mainly to force the new growth of wood and bark across the cavity.

When an injury or wound (except one naturally protected) has been allowed to remain untreated for a year or more, wood-decaying organisms almost invariably produce an area of decay beneath the exposed surface of the wood. If untreated, this area increases in size and depth until it may so weaken the limb or tree that a storm will break it at the weak point, or the decay may have developed to such an extent that any attempt at treatment would be a waste of time and money. Such areas of decay often are aggravated and increased by the presence of insects, particularly borers and ants. All such regions of decay, if they are treated at all, should be attended to promptly for best results. Irrespective of the size, age, or location of the decayed or diseased area, the first steps toward checking it are practically identical in all cases. They may be regarded as comprising two essential operations: (1) Excavating decayed and diseased wood, and (2) sterilizing and dressing cut surfaces.

The necessary tools for digging out the decayed wood are few. As a rule, two outside-ground socket-handled gouges, a chisel, a mallet, a knife, and an oilstone are sufficient for ordinary work. One gouge should have a curved cutting edge of about an inch, and the other one of perhaps 1½ or 2 inches. A smaller and stouter gouge may have to be used in trees that have very hard wood, e.g., live oaks, etc. The gouge, chisel, and knife should never be used on the bark or near the cambium when they lack a keen edge, as dull tools may easily injure the latter. In cutting out deep cavities, longer interchangeable handles for the gouges may be necessary. A ladder or a stepladder may be required if the work is more than 5 or 6 feet from the ground. As the work progresses, the desirability or convenience of having certain other implements will often become evident.

EXCAVATING

One of the fundamental principles in controlling disease (whether of animals or plants) is to remove, destroy, or render harmless the organism causing the disease. Decay or rot in trees is caused by various specific organisms. These must be removed, killed, or otherwise rendered harmless, in order to stop the progress of the decay. In trees the diseased tissue is usually removed by cutting. But cutting out the decayed tissue alone is not sufficient. All wounds must be protected against reinfection and, what is equally important, cracks that appear as a result of surface-drying after the work is completed must be plugged or covered as indicated later, for reinfection of wounds may take place in these cracks.

Usually an old neglected area of decay is partially or wholly covered by a comparatively recent growth of wood and bark around the edges, and the visible portion may be comparatively small (fig. 11). In such cases it often is necessary to enlarge the opening, in order to have sufficient room in which to gouge out the interior. This opening should not be made any wider than necessary, as it materially reduces the flow of sap by severing additional sap-conducting tubes (p. 3), but it can be made sufficiently long to reach all the decayed heartwood with little or no additional injury to the conducting tubes. The opening should be pointed at both ends. If much living sapwood is cut away at the sides of an opening during the growing season the foliage of the tree should be reduced proportionally by pruning or by stripping the leaves sufficiently to prevent wilting.

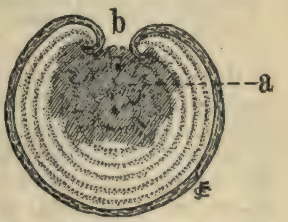

FIGURE 11.—Section of a tree with an old wound partially healed over, showing (*a*) a large decayed area with (*b*) only a small opening visible from the exterior. In excavating the decayed area the cavity should be extended back in all directions into sound wood.

The most important part of this work is to remove the diseased, decayed, or insect-eaten wood, or otherwise check the growth of the fungus organism. Excavating should be continued until sound and uninfected wood is reached. All discolored or water-soaked wood should be removed, unless such excavating is liable to seriously weaken the tree, as this is the region in which the rot-producing fungi are usually most active. Infected wood usually extends some distance beyond the visibly discolored portion. In decayed areas of many years' standing there may be only a thin shell of healthy wood around the cavity, in which case there is danger of the tree being broken by storms unless braced, guyed, or crown-pruned. Unless there is some very special reason for attempting to prolong the life of such a tree it is better to have it removed and replaced by a healthy one.

SHAPING THE CAVITY

All parts of the cavity should be shaped so that it will be impossible for water to remain in any hollow. When the cavity extends below the surface of the ground (rarely at other times), it is not possible to drain it in this manner. Under such conditions the lower part of the cavity should be filled to a few inches above the level of the ground, and the top of the filling sloped so as to throw the water out of the cavity in case the whole cavity is not to be filled. Asphalt and sawdust (or asphalt and sand) are excellent mixtures to use in such places (p. 31).

It is doubtful practice to have a deep water pocket at the bottom of a cavity with drainage provided through an auger hole bored from the exterior. An open untreated hole of this sort commonly becomes a favorable lodging place for insects, fungous spores, yeasts, and bacteria, resulting in slime flux. Such organisms usually readily infect the wood back of the filling by growing through the hole.

As already emphasized, great care must be exercised in working around the cambium, and all cutting tools must be kept very sharp. The final cutting along the edge of the bark and sapwood can often best be made with a very sharp knife or drawshave. This cutting must be followed immediately by a coating of shellac, which should cover the cambium and a narrow strip of the bark and the adjoining sapwood (p. 19).

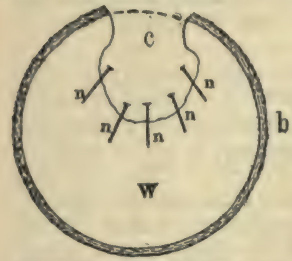

FIGURE 12.—Section of a tree cavity, showing how it is undercut at the margins to assist in holding a plastic filling in place; it also shows nails driven into the back of the cavity for a similar purpose; *b*, Bark; *c*, cavity; *n*, nails; *W*, wood.

UNDERCUTTING

In cutting out decayed wood where the cavity is to be filled with some plastic substance the sides often may be undercut (fig. 12), so as to hold the finished filling more firmly in place. However, when this is done care must be taken that the wood at the edge of the opening is not very thin, as this promotes the drying out of the sapwood and bark at these points. Ordinarily the edges should be at least three fourths of an inch thick (1½ inches is better). When possible it should include the full thickness of the sapwood. Usually the inrolled bark and wood at the sides of an opening will have to be cut away, in order to remove the decayed and infected wood. As a substitute for the undercutting (when a substitute seems advisable) one or more strips of wood can be nailed around the cavity, the outer surfaces of which are level with the cambium (fig. 13), or slightly below it. These strips should be painted with tar or asphalt so as to waterproof them.

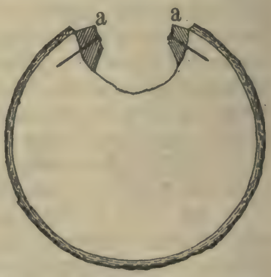

FIGURE 13.—Section of a tree cavity, showing how strips of wood (*a*) can be nailed along the edges to prevent the inrolling of the new callus growth and at the same time to hold a plastic filling more firmly in place. In open cavities the back edge of the strip should be beveled, as indicated, so as to allow ready inspection of all parts of the cavity; in cavities to be filled, the back edge should not be beveled.

STERILIZING

After the decayed and diseased matter has been excavated and the edges of the sapwood and bark adjoining the cambium shellacked, the remainder of the cavity also must be sterilized. As already stated (p. 21) creosote appears to be one of the most efficient preparations to use. Every exposed part of the wood and bark must be sterilized, and over this and the shellacked portion a heavy coating of tar, hot asphalt, or some other suitable dressing applied.

This completes the essential operations in cavity work. Filling a cavity is of much less importance and in many cases entirely unnecessary.

OPEN CAVITIES

A cavity that has been properly cleaned, sterilized, and dressed in the manner already described is in condition to be left, with annual or more frequent inspection, in comparative safety for years. The new growth of wood and bark along the margins will gradually form an inwardly rolled edge if there is no filling or artificial ledge (fig. 13) to force it across the cavity. This growth may not be objectionable if the crevice back of it can be kept clean and free from insects. Such a growth of inrolled wood commonly stiffens the trunk more than the average filling, for it acts much the same as an H- or T-beam in structural work, and it has the normal flexibility of the wooden trunk. Practically all shallow cavities should be left open, for with few exceptions there is no safer, simpler, or more satisfactory method of handling them.

An open cavity may be regarded as a hollow wound. All the precautions regarding inspection and repair mentioned in the italicized paragraph on page 23 and in the paragraph following it apply with even more force here than they do in the case of flat wounds.

BOLTING

Crotches in trees are often split during a heavy windstorm, or by the weight of snow or ice. Sometimes the wood above or below a cavity will split, perhaps from a sudden cold snap (frost crack) or from other causes. In such cases, where it is possible, bolts should be used to pull the parts together and close the crack. Under most conditions, particularly in large trees, it will be necessary to pull the limbs together so as to close the crack properly before boring the hole for the bolt. This may be accomplished by using a rope and tackle blocks some distance above the crotch. When tackle blocks are used care must be taken to have an abundance of bagging or other padding between the bark and the encircling ropes, or, better, a short piece of heavy belting a few feet in length, with a heavy metal loop at each end for attaching to the tackle blocks, can be used. Another method, particularly when tackle blocks are not available, is to loop a stout rope around the two well-padded limbs and tie the ends firmly together. A heavy or stiff bar is then placed between the two parallel portions of the rope about midway between the two limbs and used to twist the rope, thus drawing the limbs together sufficiently to completely close the crack, after which the holes are bored and the nuts screwed up tightly before the rope is untwisted and removed.

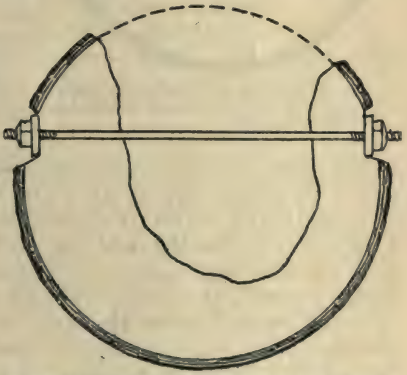

FIGURE 14.—Section of a large tree cavity, showing how a single bolt should be placed to hold the sides rigid.

Often a single bolt can be used for this purpose (fig. 14). In certain cavities or crotches it may be necessary to place bolts at different angles (fig. 15). In either case a strip of uninjured bark and cambium at least an inch wide should be left between the edge of the cavity and the end of the bolt, if it is possible to do so. On medium-sized trunks, after deciding where bolts can most efficiently be placed, a sharp bit (or auger) a half inch or more in diameter and sufficiently long to reach through the trunk and cavity can be used to bore the hole for the bolt. On large trunks a larger bit should be used, and it may be necessary to bolt, weld, or otherwise fasten on an extension to the shank of the bit. This can be done by any good blacksmith, machinist, or garage worker.

Iron or steel washers (preferably oval) about three times the diameter of the bolt (fig. 16) may be countersunk into the wood by carefully cutting away the bark and wood at both ends of the hole with a sharp gouge or chisel. The washers should be ample and heavy, but not so broad as to make it necessary to cut away an excessively large piece of bark. In most trees when round washers are used it is advisable to have the bark adjoining this countersunk area somewhat pointed above and below the washer (fig. 17). By holding the two washers in place, the length of the iron or steel machine bolt can be measured through the hole. The bolt must be thick enough to fit snugly in the hole and should project beyond each washer at least one fourth of an inch. The thread at each end of the bolt must be coarse and sufficiently long to permit drawing in the sides of the cavity as the nuts are screwed up firmly against the washer. A chamfered single-headed bolt may be used if preferred. Before the bolts are finally put in place the countersunk cuts and bolt holes should be tarred or creosoted, and after the bolts are in place all exposed parts of wood, bolts, and nuts should be waterproofed. If the washers and nuts are sunk deeply into the wood the holes at the ends of the bolts may be filled with cement or asphalt to the level of, or slightly below, the cambium. This will make a neater looking job and leave the spot in better condition for healing over with a smooth surface, but a socket wrench will have to be used to tighten the nut. In some cases a threaded bolt without nuts will be sufficient.

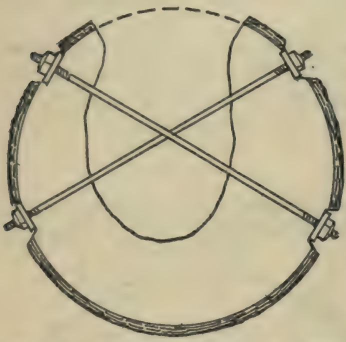

FIGURE 15.—Section of a large tree cavity, showing how two bolts should be placed to hold the sides rigid.

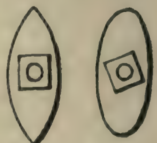

FIGURE 16.—The ends of two bolts with oval washers. The long diameter of the washers should run lengthwise of the trunk or limb.

All split cavities must be securely bolted, particularly near the upper part, after the limbs are drawn together as already described. If the split is an old one and comes from a crotch, all decayed and diseased wood should be removed from the split and an antiseptic wash and dressing applied, after which it can be bolted just beneath the crotch (fig. 18, *a*), so as to hold the parts in their original position. If the limbs are large and heavy a second bolt (fig. 18, *b*) may be necessary above the crotch. It usually is advisable to fill (as described on p. 30) any cavity left in a crotch after it has been properly treated and bolted, and often also to guy the limbs above the crotch. If the split is a recent one, an antiseptic wash alone usually will be sufficient before bolting the sides together. Except on heavy work or when a crack is to be closed by means of bolts and nuts, washers often are unnecessary. Some commercial workers use a coarsely threaded bolt which is screwed tightly into the hole and no nuts are used. Finally, all exposed edges of the crack must be covered with a waterproof dressing. If necessary, limbs above split crotches may be guyed above the bolts (p. 15).

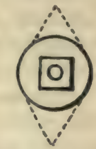

FIGURE 17.—The end of a bolt with a round washer. Triangular pieces of bark should be cut away above and below the washer, as indicated by the broken lines.

COVERED CAVITIES

Sheet tin, zinc, copper, iron, and other metals, as well as canvas and various other materials, have been used to cover cavities. When properly applied, these coverings often assist in keeping out disease, decay, and insects for a long time and usually assist in forcing the new growth across the opening. If the covering has been done improperly or if the cavity itself has not been properly treated, a covered cavity is a much greater menace to a tree than an open one.

In preparing a cavity for a covering, all the decayed, diseased, and insect-eaten wood should be removed in the manner already explained, with two modifications: (1) It is not necessary to undercut the edges of the cavity, and (2) there should be a narrow half-inch ledge of wood around the margin of the cavity from which the bark has been removed and to which the edge of the covering can be tacked (fig. 19). The cavity must be thoroughly sterilized and dressed, in the way already described. Sheet metal or other coverings should be trimmed so as to fit the opening, but should leave a strip of bare wood one sixteenth to one eighth of an inch wide between the edge of the metal and the edge of the bark. This often can best be done by making a heavy-paper pattern to fit the opening, allowing it to curve outward to conform to the general shape of the trunk or to curve inward so as to allow for contraction or expansion of wood during sudden changes of temperature. The metal can then be cut the same shape as the paper pattern. By placing the metal on a block of wood, holes a half inch or an inch apart can be punched or drilled along the margin, through which slender flat-headed brads or nails may be driven into the ledge of wood around the cavity, or if the metal is not too hard the nails may be driven directly through the metal. The inner side of the metal should be freshly painted, preferably with asphalt or tar, the entire cavity already having been properly treated. The metal should be put in place and nailed with a light hammer. Two or more pieces of sheet metal with overlapping joints should never be used unless these joints are soldered airtight. If all insect tunnels have not been cut out, the cavity should be fumigated by saturating a wad of cotton or cotton waste with carbon disulphide and suspending it with a string in the top of the cavity for 12 hours or more before the metal is permanently nailed to the wood at the top. Carbon disulphide should not be used near a fire or an open light, as under such

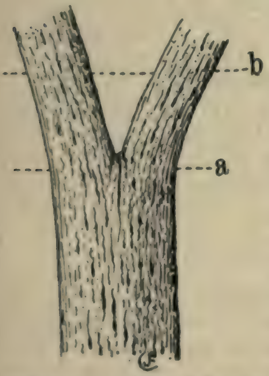

FIGURE 18.—A split crotch; the dotted lines *a* and *b* indicate the position in which bolts should be placed to hold the split.

circumstances it is very inflammable.[4] Carbon tetrachloride is sometimes used instead of the disulphide. This is noninflammable but less effective, and more of it has to be used. One or two teaspoonsful of the carbon disulphide usually will be sufficient for each cubic foot of cavity. During the fumigating process the cavity must be tightly closed and sealed with putty, clay, or some equally effective substance.

The final operation is to waterproof the outer surface of the covering, the edges of the bark, and the strip of wood between them, taking special care that the tacked edges of the metal are made as airtight and insect-proof as possible. During all parts of the operation every possible precaution should be taken to prevent the cambium from being bruised or unnecessarily cut. Such covered cavities should be closely watched for defects, particularly about the edges of the cover, and any defects detected should be immediately repaired.

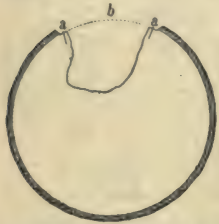

FIGURE 19.—Section of a tree cavity, showing the marginal ledge of wood (*a*) to which a sheet of metal (*b*) can be tacked to cover the cavity.

FILLED CAVITIES

Cavities made by cutting out decayed wood may be filled in various ways with various materials, if for any reason it seems best to fill them at all. Three methods of doing this are described in the following pages. The principal object of any filling is to prevent the new growth of wood and bark from rolling or curving into the cavity, and to assist this new growth in reaching across the cavity more quickly. Fillings do not ordinarily materially strengthen the trunk or limb, as many people suppose. In this connection it is well to remember two things: (1) That a very large or wide cavity will rarely if ever completely heal over, certainly not for many years, and (2) that the uncut callus growth that rolls into a hollow trunk from the edges of an unfilled cavity probably strengthens the trunk more than any filling that involves the cutting away of this callus growth.

FILLING CAVITIES WITH CEMENT MIXTURES

The material most commonly used in this country for the past 25 or more years to fill tree cavities has been cement mortar or concrete. This material is not recommended for filling all cavities. However, as it often holds fairly well in small globular cavities, or even larger cavities in the roots or base of the trunk where there is practically no movement when the wind blows, and the material is so readily obtained and easily worked, a brief description of one of the simplest methods of handling it is included here.

A cavity that is to be filled with cement should be prepared as indicated on page 24, particular care being given to undercutting or bolting, or both, in larger cavities. Bolts serve not only to support the walls of the cavity but also to prevent the hardened blocks of cement from falling out when there is little or no undercutting, or when the filling becomes loosened by the bending of the tree. In the latter case the bolt is a disadvantage, for a tree is better off if a loosened filling is not held in place. Another way to hold the cement in place is to drive large nails or staples half their length into the back and sides of the cavity, so that the projecting heads are finally embedded in the hardened cement (fig. 12).

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[4] See Farmers' Bulletin 799, Carbon Disulfide as an Insecticide.

A good grade of portland cement and clean sharp sand free from loam should be used. One part of the dry cement and 2 or 3 parts of the sand should be thoroughly mixed before adding sufficient water to allow its being worked into a stiff mortar. This mixture is put into the cavity with any suitable trowel and lightly tamped into a close contact with the dressed walls of the cavity. After partially setting, the surface can be worked over with the trowel until moist and smooth. The surface of the finished filling should be no higher than the cambium, as indicated by the dotted lines in figures 12, 14, and 15. Preferably it should be finished about an eighth of an inch below the level of the cambium and the exposed wood at the edges kept thoroughly waterproofed until the new callus has grown down into close contact with the cement. If the cement mixture is too thin it may be necessary to hold it in place until partially set. A simple way of doing this is to wrap a piece of heavy cloth around the lower part of the cavity, keeping it loose enough to allow it to curve outward to about the contour of the trunk when the cement is tamped into place back of it. Before the cement has fully hardened, this cloth dam should be removed, and the cement finished back to just below the cambium line.

FILLING CAVITIES WITH ASPHALT MIXTURES

For covering large wounds as well as for dressing cavities, asphalt apparently is not excelled by any other substance mentioned in this bulletin. The asphalt (also called asphaltum) is the residue of the distillation of some of the western petroleums, and varies in melting point from the boiling point of water upwards. It is a black, essentially solid substance, which when cold can be slightly impressed with the end of the thumb nail. The firmer and harder grades (sometimes know as "mastic") are usually preferred, provided they are not hard enough to crack when struck a sharp blow with a hammer. The greatest objection to its use is the fact that it has to be kept melted and used while hot, unless mixed with some solvent. This makes the process cumbersome and inconvenient, which in itself is a serious objection from many points of view, although a coating of clear asphalt, properly applied at the outset, will often last for years without renewal.

As an ingredient of a cavity filler asphalt has few, if any, of the objections mentioned above for cement, because its elasticity and resilience prevent cracking, and it is absolutely waterproof. It is very adhesive and does not readily separate from the wood when properly applied. For filling a cavity it should rarely be used clear, but in combination with coarse, dry hardwood sawdust, excelsior, shavings, sand, asbestos, crushed shells, or some other suitable substance.

An outline of two methods of using a mixture of asphalt and sawdust to fill a cavity will serve in general for the other mixtures mentioned. The first method will be more useful when a fire or stove can be used near the tree, and the second where this is impracticable, as, for example, on a well-kept lawn or near shrubbery that might be scorched by the heat. However, neither method is recommended in preference to the wood filling described in the next section, owing primarily to the difficulty of getting a mixture stiff enough not to slump when exposed to hot summer sunlight.

First method.—Thoroughly melt the asphalt in a kettle or other suitable receptacle and slowly stir in coarse, dry hardwood sawdust. Continue adding the sawdust as long as the particles can be partially blackened by the asphalt after several minutes' stirring. This hot pasty granular mixture can then be placed in the cavity, which has been prepared as already described, and pressed or tamped into close contact with the side of the cavity before it hardens or cools. For placing the mixture in the cavity, which already has been dressed with clear, hot asphalt, a trowel, paddle, or ladle can be used. The tamping stick should have a smooth and slightly rounded end. The end may be covered with sheet metal if desired, or a tamping rod made of iron may be used. If the mixture adheres to the end of the tamping stick to an extent that interferes with the work, a quick twist as it is about to be withdrawn will usually improve conditions. It may be necessary to grease or wet the end of the stick frequently. Often the best results are obtained when a steady, slow, heavy pressure is exerted rather than a quick tamping movement. A very excellent 2-foot tamping stick can be made from a shovel handle. The grip at the end gives a ready purchase for the twisting motion. The opposite end of the stick should be rounded, sandpapered, and soaked in a lubricating oil or in hot tallow for some hours before being used.

Second method.—Mix the asphalt and sawdust in a kettle, as described above, over any suitable stove or fire anywhere that may be most convenient. When thoroughly mixed, dip it out of the kettle and place it on sheet metal to cool in the form of pancake-shaped or biscuit-shaped lumps, whichever form may be the most conveniently used or handled. The sheet metal may be greased or not. The asphalt mixture can be removed when cold by tapping the metal or, if necessary, by applying a blast torch to the back of the sheet metal. Another and often more convenient way of preparing the lumps is to drop the hot mixture into shallow molds made in the ground or in sand, and brush off the dirt or sand when the lumps are cold. These lumps can then be transported wherever they are to be used, or they can be stored indefinitely for future use. When used for filling a cavity, they may be kept whole or broken into pieces. A blast torch may be used to soften the surface of the lump sufficiently to allow it to pack more readily into a cavity before it is pressed into place and nailed firmly to the wood, or the lump may have nails driven into it and then be partially or completely dipped in melted asphalt and immediately nailed into the cavity. All the lumps should be nailed firmly in place. Small sheets of wire netting, metal lathing, burlap, or canvas often can be nailed or stapled over different layers of the asphalt mixtures with good results; preferably so they will not show on the surface when finished. This operation, perhaps with slight modifications, is repeated until the whole cavity is filled. When the blast torch is used in the interior of the cavity care should be taken that the cambium is not overheated. A simple way of preventing overheating is to have a broad paddle of wood, fiber, or other nonconductor of heat that can be held over the cambium and bark with one hand while the torch is being used with the other. After a little practice, the torch will rarely have to be used inside the cavity.

After all the decayed matter has been removed and the cavity sterilized and properly dressed, there is no immediate danger in delaying subsequent operations if for any reason such delay seems necessary or desirable. Moreover, it is unnecessary to put all the filling compound into the cavity the same day, or the same week, or even the same month. After asphalt mixtures have cooled, the hot sticky surface can be restored by passing a hot iron over it or by protecting the cambium and using a blast torch. This heating of the surface should be done just before another batch of filling is added, especially when the first method mentioned is used.

When a cavity has been filled by either method, the surface of the filling can be finished off with a hot iron to an eighth of an inch below the level of the cambium. In no case should it be allowed to project beyond the dotted lines shown in figures 12, 14, and 15. Frequent failures of this type of filling are usually due either to an improper mixture of asphalt and sawdust or to inefficient methods of holding the filling in place. If a sufficient quantity of sawdust has not been mixed with the asphalt or if too much clear asphalt has been used to cement the lumps together when the second method is used, the composition will slowly slump, pull away from the wood at the top, and flow out at the bottom of the cavity. To prevent this slumping, the surface of the finished filling may be covered with canvas, closely woven burlap, thin strips of wood, wire netting, metal lath, or other suitable covering, and held in place with long nails, screw bolts, or staples that reach into the solid wood at the back of the filling. If the bolts, nails, or other staples are too thick to be driven through the asphalt without cracking it, they can be heated and slowly pushed through to the wood. In shallow fillings a simple way is to drive in closely set long nails, each nail passing through a large washer. As a rule, if these washers are closely set no other covering is necessary. When any of these surface coverings are used, the outer face should be no higher than the level of the cambium and should finally be dressed with tar, asphalt, or paint.

Care should be taken to avoid bruising or unnecessarily heating the cambium at any time. A very good tool with which to finish the raw surface near the cambium is a small mason's trowel, the tip of which can be heated for a few seconds at a time in the flame of a blast torch. A tool of this general shape with a thin edge but with more metal at the center is better and will hold the heat longer. For finishing farther away from the cambium a larger and heavier tool will be more useful, e.g., an old-fashioned flatiron. If masses of asphalt project too far beyond the contemplated finished surface to be smoothed readily with a hot trowel, they can be cut off with a hot trowel, or with a cold chisel and hammer, before the surface receives its final smoothing.

Thinner mixtures of asphalt and sawdust than indicated above (or even clear asphalt) may be used when the cavity is so situated or shaped that the mixture cannot run out if softened by a high temperature. This applies particularly to cavities on the upper side of a nearly horizontal limb and to those extending downward from an opening in the trunk or in a crotch. However, in most deep cavities a better method is to fill roughly with wood (see next section) to about an inch or less back of the cambium and finish with an asphalt mixture, as just described.

FILLING CAVITIES WITH WOOD

Asphalt or asphalt mixtures can be used along with blocks or strips of dry wood (such as laths or scantlings) for filling cavities. When blocks or strips of wood are used as the main filling substance they can be trimmed roughly to fit into various parts of the cavity or into the whole cavity and painted with asphalt or tar so as to waterproof them before they are nailed in place. An entirely satisfactory way to do this is to cut a strip of the desired length with a handsaw and then use only a small, sharp hand ax and small chopping block to trim it roughly to fit the desired place, then remove it from the cavity, and drive the required nails or staples part way through it.

The back of the block or strip and that portion of the cavity in which it is to be placed should be covered with a thick coat of hot asphalt, and the strip nailed in place. If the wood strips used are soft or easily split, it will be safer to use coal tar, as cold asphalt will sometimes cause the wood to split before the asphalt will yield. If the wood should split, the crack should be filled with coal tar. A long heavy nail set, a center punch, or a saddle punch may be useful in driving the nails or staples into the strips. At times it may be advisable to use screws or bolts instead of nails or staples. The blocks or strips of wood need not be very carefully fitted, because the asphalt mixtures, particularly asphalt and sawdust, will fill practically all spaces between them. It usually does no harm if some spaces are not filled, provided they are not at the surface of the filling. The grain of the blocks or strips may run lengthwise of the trunk and extend the entire length of the cavity, at least when near the surface, or it may run across the cavity, or in different directions in alternating layers. Each method seems to hold equally well.

In large cavities, when the grain of the strips runs lengthwise of the trunk, a strip or layer of strips an inch or two thick may first be placed in the back of the cavity and then the building up done mainly from the sides (fig. 20). If such a filling is planned so that there will be an unnailed but thoroughly asphalted closely fitting joint extending the length of the cavity and from the layer of strips first nailed to the back of the cavity to its outer surface (fig. 20, *a–c*), there will be very little danger of the filler pulling away from the sides of the cavity as a result of a contraction of the sapwood during a cold spell. In such a filling the opening, if it comes, will be along the line of least resistance, which in this case will be, almost invariably, the unnailed joint lengthwise of the filling. In section this joint may be a straight or a zigzag line, preferably the latter. As the crack closes when the weather becomes warmer the asphalt will usually cement the two edges of the joint together again; but even if it does not, both surfaces of the crack still will be covered with waterproof asphalt.[5] If the strips of wood used in the cavity are creosoted before they are put in place, the danger of infection as a result of wetting is still further safeguarded. The exposed surface of the completed filling should be trimmed back to about one eighth of an inch below the level of the cambium, either before or after the strips are nailed in place, so as to conform more or less closely to the shape of the trunk (fig. 20), and finally painted with hot asphalt, coal tar, or paint of any desired color.

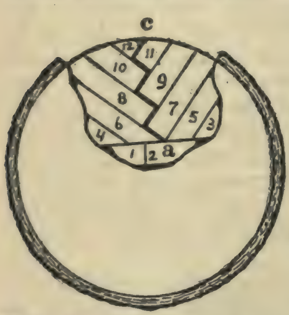

FIGURE 20.—Section of a tree cavity filled with strips of wood. The numbers on the strips indicate the order in which they are inserted. No nails are driven across the zigzag line *a–c*.

For keeping the asphalt melted, some sort of heater will be required. In most cases one that is readily portable will be most useful, for the asphalt can usually first be melted over some less portable heater or stove and the portable heater used merely to keep the asphalt melted while it is being used. Often it will be most convenient to have a rather small heater, such as some blast torch, or a plumber's or tinsmith's stove—possibly one that can be suspended by a padded wire from a limb of the tree. A galvanized-iron pail with a capacity of about 10 quarts or less may be useful for this purpose. The bail socket should be riveted to the pail. With a little ingenuity one of the heaters mentioned above can be altered so that it may be suspended by means of two long hooks to the bail sockets of the pail or to the top of the pail, and the pail and the attached heater carried about by the bail, yet the two can readily be separated if desired. The pail and heater can be suspended from the limb of a tree by a padded hook, or the heater can stand on a board on the ground and the pail be set on top of it.[6]

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[5] Excellent preparations to use between the strips of wood, containing asphalt and asbestos, can readily be purchased of dealers in roofing materials or flashings, and they have the advantage of being mixed ready for use without heating. At times it may be an advantage to mix sawdust or some similar substance with them.

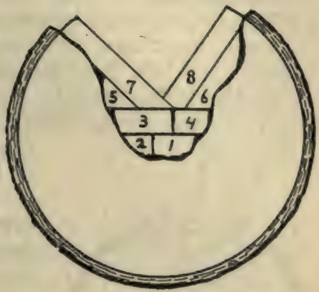

FIGURE 21.—Section of a tree cavity partially filled with strips of wood. The numbers indicate the order in which the strips are inserted.

Oftentimes it is neither necessary nor desirable to fill a cavity completely; or perhaps the necessary time to complete the work promptly is not available. Under such conditions the cavity can be cleaned out, sterilized, and dressed. If an inrolling callus is objectionable, strips of sterilized or waterproofed flexible wood can be nailed along the edges of the cavity, the outer edge of the strip being no higher than the cambium line (fig. 13). In most cases if this strip is a half inch thick it will for some time prevent the new callus growth from rolling into the cavity, and before the new growth has reached across it another strip can be nailed over it, or the cavity completely filled. If these strips are used it will be necessary to fill the small pocket back of the strips at the bottom of the cavity with wood or some plastic substance, so that it will not hold water.

If it is impracticable or inconvenient to use hot asphalt and sawdust or some of the commercial materials between or behind the strips of wood in filling a cavity, a substitute can be found by mixing sawdust with creosote and asphalt (p. 21), or with coal tar, or even with paint. Perhaps the best home-made substitute for the heavy asphalt is a mixture of coal tar and dry sawdust. This mixture does not necessarily have to be heated during any part of the operation unless the work is done in very cold or freezing weather. It is better, however, to have the tar hot when the sawdust is being mixed with it. No definite proportions for the tar and sawdust can be recommended, because the quantity of each ingredient is largely dependent upon the grades and kinds of sawdust and tar that are used. In his own work the writer has found that 1 part of thoroughly dry sawdust by weight to 3 or 4 of coal tar or 3 to 4 parts of sawdust by bulk to 1 of coal tar give a mixture of about the right proportions. The mixture should be stirred (preferably when warm) until it is of an even consistency—somewhat granular but sticky and pasty. When put in the dry cavity, it should readily stick but should not be thin enough for the tar to ooze out, at least not until the mixture is compressed by nailing or stapling the wood strips firmly in place over it. It will be advisable

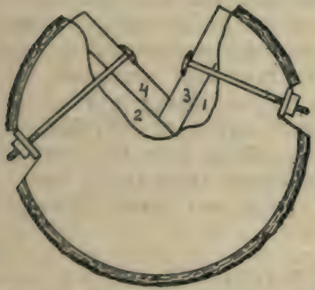

FIGURE 22.—Section of a tree cavity partially filled with strips of wood; these are bolted to the walls of the cavity. The numbers indicate the order in which the strips are inserted.

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[6] See footnote 5.

to paint with clear coal tar the exposed wood, the strips that have been fastened in the cavity, and the back of the strip that is to be inserted before inserting the sawdust and tar mixture (p. 35).

Generally, when the strips run lengthwise of the cavity, some such arrangement as is shown in figures 20, 21, and 22 will be found most advantageous, as such an arrangement permits more freedom in driving the nails or staples, or in placing the screws or bolts in position through the strips. The edge of the strips at the surface should be trimmed off in a line no higher than the cambium, as shown in figure 20, or the strips may be trimmed back to a line behind the cambium and 1, 2, or more thin strips of sufficient thickness to bring the surface nearly up to the cambium line nailed, screwed, or bolted over it to form an outside layer, as shown in figure 23. Another method is to replace the strips numbered 11, 12, and 13, in figure 23, with a layer of asphalt and sawdust, as described in the preceding section. The order in which the strips may most conveniently be placed in the cavity is indicated by the order of the numbers on the strips in figures 20, 21, 22, and 23.

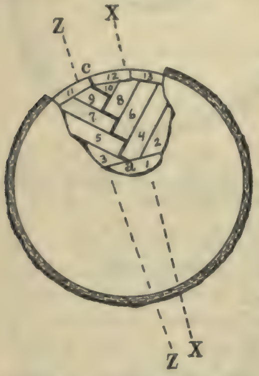

FIGURE 23.—Section of a tree cavity filled with strips of wood, with a thin surface layer of strips (nos. 11, 12, 13). The broken line *X–X* indicates where a bolt, when necessary, should be located to hold the ends of a filling, as indicated in figure 21. Occasionally it may be necessary to place bolts at both *X–X* and *Z–Z*. No bolt should pass through the unnailed zigzag joint *a–c*.

In long fillings, particularly in flexible branches when the grain of the wood strips runs lengthwise of the cavity, a bolt and metal washer near each end of the filling, and perhaps another at the center, will prevent the ends or center working loose. Figures 22, 23, and 24, with their legends, will explain the details of placing the bolts and washers. The bolt and washers will rarely be needed when the grain of the wood runs across the cavity or when alternating layers of strips are at different angles to the adjoining layers. If the smooth surface of any type of filling is esthetically objectionable it may be carved, modeled, or painted to imitate more or less closely the natural bark, but if this is done the surface of the filling should not cover the edge of the cambium at any point.

COMPLETED WORK NEEDS WATCHING

Tree owners and superintendents of trees in parks, on streets, and on other public land often neglect to keep close watch of their trees, in order that defects which appear in the work may be repaired promptly and new injuries elsewhere on the tree may have immediate attention. This statement applies to all pruning wounds and cavities, either filled or unfilled. If a tree is of sufficient value to warrant proper and careful treatment, it certainly is worth the slight expense of subsequent annual inspection and the immediate treatment of newly discovered injuries at a time when the necessary outlay to keep the tree in good condition will be comparatively small (p. 13). Opera or field glasses will be an aid to any such inspection made from the ground.

PERSISTENCE OF SCARS

It should be borne in mind that scars where large limbs have been removed, or large cavities filled or left open, will be unsightly spots to the majority of people for years, even under the best of conditions. If the scar is a large one, it may never entirely heal over before the tree succumbs to other destructive agencies, and consequently it may remain a permanently conspicuous defect (p. 4). It might so happen that a large scar or filling would be too unsightly and conspicuous to please the owner. Here, again, greater satisfaction may be realized in the end by having the diseased tree replaced by a healthy one.

COMMERCIAL WORK

If a tree owner prefers to employ a commercial worker to attend to his trees, it may be advisable to have a definite written contract concerning at least certain important phases of the work, in addition to specifying the price and the methods of payment. Besides the type or types of finished cavity work, the following are suggested as points that may be incorporated in the contract—points to which no reliable tree worker ought to object:

(1) No climbing spurs shall be used on any part of a tree.

(2) The shoes worn by the workmen shall have soft soles.

(3) In cavity work all diseased, rotten, discolored, watersoaked, or insect-eaten wood shall be removed and the cavity inspected by the owner or his agent before it is dressed.

(4) Ordinary commercial shellac (p. 19) or some other efficient covering shall be applied to the cut edges of sapwood, bark, and cambium within 5 minutes after the final trimming cut is made, or as soon afterwards as the surface becomes sufficiently dry.

(5) All cut surfaces shall be painted with shellac or creosote, followed by thick coal tar or asphalt, or other equally permanent covering.

(6) The contractor shall repair free of expense any defects that may appear in the work within 2 years.

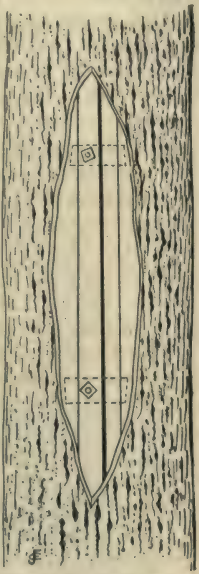

FIGURE 24.—Surface view of a tree cavity filled with strips of wood, as shown in section in figure 20; the surface has not yet been waterproofed. The broken lines show the position of the bolts and the broad washers. The washers should be of heavy iron and wide enough to reach across all the strips at the point where they are placed. The bolts should not pass through the unnailed joint *a–c* indicated in figures 20 and 23.

Under certain conditions various modifications of these suggestions may be advisable, but alterations in nos. 1, 2, 3, and 6 should be made with caution. If certain crotches are split or particular limbs on some trees need bracing, it may be well to include a statement of just what limbs shall be removed from particularly choice trees. And, last but not least, some provision should always be made for the regular inspection of the trees every year, unless the owner or the superintendent of street and park trees prefers to do this himself.

ADDITIONAL INFORMATION AND SUGGESTIONS

The treatment of tree wounds has not received the support that it warrants from tree owners and officials in charge of public grounds, including streets and roadsides. This at times may be due to unfavorable experiences with ignorant tree workers, particularly in regard to cavity work; at other times to the reluctance of the owners to spend much money in preserving their trees, or to ignorance of the benefits that may result when the work is properly done. Reliable and conscientious tree workers are doing much in a practical way to show the public that injured trees will favorably respond to proper treatment.

The practice of treating tree wounds is very old and probably all of the best methods are well known. Tree owners should regard with suspicion all persons or firms who claim or intimate that the work is a secret art. They should be particularly cautious about allowing persons to work on their trees who claim to have secret methods of curing or treating disease, decay, or insect injuries in trees. Cases still are occasionally reported where tree owners have been victimized by fakirs who bore holes into tree trunks and insert some reputed secret "cure-all" preparations.

A few States, notably Connecticut and Rhode Island, have laws regulating work on a commercial basis. This is a decided step toward improvement and standardization of methods and better cooperation among workers.

The Department of Agriculture invites correspondence concerning methods in treating trees that have been injured. By cooperation of this sort the practice of tree treatment ought ultimately to attain a higher place in the estimation of the general public than it now holds.

Finally, tree owners are urged to remember at all times that the necessity for extensive work on a tree 15 or 20 years hence may be reduced very materially by promptly attending to the fresh injuries of today.

It is believed that the methods described in this bulletin are not covered by letters patent granted to any individual, firm, or corporation, but the Department of Agriculture assumes no responsibility in this connection.

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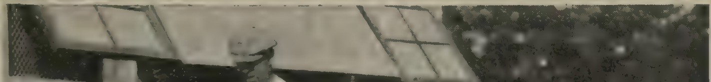
U. S. DEPARTMENT OF AGRICULTURE
FARMERS' BULLETIN No. 1727

SELECTING HENS *for* EGG PRODUCTION



A LARGE NUMBER of eggs produced per bird is one of the most important means of obtaining good returns from poultry. Bred-to-lay stock is of primary importance in obtaining good egg production.

Improper methods of feeding and management of the laying stock interfere with efficient selection.

The proper selection of hatching eggs and young stock is essential if satisfactory egg production is to be obtained from a pullet flock.

Research has indicated that there is no relationship between egg production and the measurements of the head and body. A hen's ability to lay is determined primarily by her breeding.

In selecting the good producers and in culling unprofitable birds, it is necessary to be able to distinguish hens that are laying from those that are not. The condition of comb, wattles, vent, and other parts indicates whether a hen is laying at a particular time. The bleaching of the pigment of the vent, beak, and shanks, the time of year that molting takes place, and the duration of the molting period are useful factors in determining how long birds have been laying. The earning capacity of the flock can be kept at a high level by the frequent elimination of nonlayers.

A few years of intelligent selection, based on the factors mentioned, or the purchase of new stock from sources where such selection is practiced will lead to the development of high-laying strains. The birds will be noteworthy for earliness of sexual maturity, good rate of laying, comparative absence of broodiness, and persistence of production. These four characteristics largely determine the number of eggs produced.

Washington, D.C. Issued May 1934

SELECTING HENS FOR EGG PRODUCTION

J. P. QUINN, *chief scientific aid, Animal Husbandry Division, Bureau of Animal Industry*

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RELATION OF SELECTION TO PROFITS FROM POULTRY

FARMERS and commercial poultrymen would get better returns from their flocks if they examined them frequently and removed the unprofitable birds from time to time. Since poultry profits are directly related to egg production, income over feed cost rises much more rapidly than expenses as egg production in a flock increases. Though the cost of maintaining a high-producing flock is somewhat greater than that of maintaining a low-producing flock, the increased production is obtained at a lower cost per dozen eggs.

Selection should begin with the hatching eggs and continue throughout the lifetime of the fowls. Emphasis is placed on the term "selection" rather than on "culling" because "cull" is used to describe two different classes of fowls. Market men, by this term, mean a bird of very low market quality. On the other hand, commercial poultrymen and farmers speak of a "cull" as a poor layer eliminated from the flock. Such culled birds frequently make satisfactory market poultry. Rigid selection of hatching eggs is the first step in building up a profitable flock. Chicks should be hatched only from good-sized eggs of the best layers; select eggs that weigh approximately 2 ounces each. Tinted white eggs and extremely light brown eggs, as well as those irregular in shape or poor in shell texture, are undesirable for hatching purposes. Chicks hatched from such eggs are likely to be a liability to the flock because of low market returns from the eggs.

Remove inferior chicks as soon as they are hatched and continue the practice until the flock is grown. Kill any weak or crippled chicks at hatching time. In order to carry on the selection of the flock most intelligently keep a record of the date the chicks are hatched, so that the age of the birds may be known during the growing season and after maturity. At hatching time the chicks may be toe-punched or banded in the wing or on the leg with a numbered leg band.

The number of unprofitable layers will be considerably reduced if runty and slow-growing birds are eliminated from time to time. Even when this is done it will probably be more profitable to cull out and sell 10 percent of the remaining, late-maturing pullets rather than to place them all in the laying house. Most farmers and commercial poultrymen do not select their young stock rigidly enough.

Close, daily observation of the laying flock during the winter months should enable the poultryman to eliminate the poor layers. In the spring watch for broody hens and either send them to market or band them in the way described later. Some of the adult breeding stock will not be valuable enough to carry over another year and may be marketed. Prices of fowls are usually higher in the spring than late in the summer.

In late June or early July, toward the end of the first laying year, market the early molting birds and any others that are not laying. Continue to do this throughout these 2 months, so that hens will not be kept in the flock after they have stopped laying. Selling the nonlayers during these months has two advantages. One is that, as mentioned above, fowls usually bring less money late in the summer than early in the season on account of increasing supplies of young poultry. The early marketing of nonproducers, therefore, should result in better returns for the fowls sold. The other advantage is the reduction of feed costs for the flock. A hen, whether laying or not, will eat from 6 to 7 pounds of feed a month. A 50-percent production in the flock (an average daily egg production equal to one half the number of hens in the flock) may be maintained during the summer months if the early molters are removed and marketed at regular intervals. Hens laying well in June and July at the end of their first laying year should be kept, since egg prices usually begin to rise during those months. If later examination shows that some of these hens are falling off in production they may be marketed. Hens laying in August and September are the most persistent layers and should be retained for a second year of production and for breeding purposes.

Production during the second laying year is usually about 20 percent less than that during the first year. Because of this fact, it is unprofitable to keep most hens longer than 1 year. On the other hand, some birds in almost every flock will lay enough eggs to be profitable a second year, and a few even a third and fourth year. The usual practice on commercial poultry farms is to retain about 30 percent of the yearling hens. In the general-purpose breeds, particularly in stock not bred to lay, more rigid selection may be practiced since there is a stronger tendency for heavy fowls to put on flesh and lay fewer eggs.

GENERAL BASIS FOR SELECTION

Flocks of poor laying ability need to be more rigidly culled than good flocks. According to the 1930 census, the average annual egg production of all hens in this country is about 90 eggs. There are many farm and commercial flocks that average approximately 150 eggs per bird and a considerable number that average approximately 200 eggs per bird. It is evident that there must be flocks that are below the 90-egg average. Low-producing flocks are relatively unprofitable largely because little or no selection has been practiced.

In order to be fairly profitable, under most conditions, a flock should average approximately 150 eggs per bird, and when proper selection increases that average the profits from the flock will also be increased. One of the most important factors affecting returns from the laying flock is the average number of eggs laid per bird.

In order that the selection of the laying flock may be most effective it is necessary for the birds to be in good health, to be well fed and well managed.

RELATION OF HEALTH TO SELECTION

In order to lay at her best, a bird must be in good health; but even in flocks where good egg production is being obtained, there are usually a few hens that have lost their constitutional vigor through the effects of disease or parasites.[1] A cold may throw a good layer out of production for several weeks. Sometimes birds become so heavily infested with parasites that it is impossible for them to lay well however good their laying ability. It is imperative, therefore, that the owner do everything possible to maintain a high level of constitutional vigor in his flock.

INFLUENCE OF FEEDING ON SELECTION

A good diet is also essential[2] in obtaining high egg production. A poor diet or an insufficient quantity of a good diet is a serious handicap. On the other hand, liberal feeding of a well-balanced diet will not enable inherently low-producing hens to make good records.

If liberal feeding of a good diet is not practiced it is impossible to tell by their appearance which hens are capable of good production. It is an easy matter to weed out the low producers in a flock that has been properly fed. If only a few hens in a flock stop laying they are likely to be naturally low producers. However, if a large proportion of a flock stops laying within a week, the decline in production is due to other causes, such as improper feeding, disease or parasitic infestation, or radical changes in management.

IMPORTANCE OF GOOD MANAGEMENT

Radical changes in flock management may throw most of the birds in the flock out of production and thus disturb the normal body changes that take place in birds under continuous production. Such a situation reduces the effectiveness of selection very materially. For instance, if artificial lighting of the laying house is used during the short winter days for the purpose of inducing liberal feed consumption and for any reason the lights are discontinued suddenly the flock is likely to be thrown out of production and perhaps into an abnormal molt. Also, if the flock is unduly excited, egg production is sure to be reduced. Then again, if the flock is accustomed to free range and is suddenly confined to the laying house, many of the birds may cease laying for a period. If the birds are deprived of water for a good part of a day, egg production is sure to drop. It is only when the flock is well managed day after day throughout the year that the selection of birds according to their laying ability can be carried out properly, as most of the principles of selection are based on body changes that take place as a result of normal laying.

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[1] For information on poultry diseases or parasites see Farmers' Bulletin 1652, Diseases and Parasites of Poultry.

[2] Detailed information on feeding poultry is given in Farmers' Bulletin 1541, Feeding Chickens.

SHAPE OF HEAD AND BODY CONFORMATION NOT RELATED TO LAYING ABILITY

Much emphasis has been placed by many poultrymen on the shape of the head as an indication of egg-producing ability. However, research at the United States Animal Husbandry Experiment Station at Beltsville, Md., indicates that there is no relationship between length, breadth, and depth of skull and the number of eggs produced or their weight. Moreover, these experiments show that weight of brain bears no relation to the number of eggs laid by a bird or to the size of her eggs. Shape of head, therefore, often regarded as an indicator of efficiency in production, is of no value in estimating a hen's laying ability.

Emphasis has often been placed also on the length and width of the back throughout its entire length, the depth of the body from the back to the front end of the keel bone, a full breast, good width in the pelvic region, and a so-called "wedge" shape, as indications of a high-producing hen. Angularity in body conformation has also been considered favorable to production. Adequate capacity in the individual to accommodate properly the vital and reproductive organs has been stressed as essential. Although differences in digestive or reproductive capacity may cause variations in production, the ability to lay depends on breeding rather than adherence to any specific type or conformation.

The results of several investigations have shown that live-bird measurements are of relatively little value for classification on the basis of egg-producing ability. Research at Beltsville, Md., has indicated that neither dressed-carcass nor skeletal measurements are significantly correlated with egg production in White Leghorns or Rhode Island Reds. Consequently, there seems to be little basis for the contention that there is an egg-laying type in the domestic fowl, type in this case meaning body conformation as indicated by the measurements mentioned.

DISTINGUISHING LAYERS FROM NONLAYERS

In selecting good producers and culling the unprofitable birds, it is necessary to be able to distinguish hens that are laying from those that are not laying. The appearance, size, or shape of the comb and wattles, vent, pubic bones, abdomen, and the lateral processes of the sternum are good indications as to whether a hen is laying.

CONDITION OF COMB AND WATTLES

The comb and wattles serve as a ready means of determining whether a hen is laying. Their color and size indicate the activity or inactivity of the ovaries. The increase in size of the reproductive organs before laying commences is accompanied by an enlargement of the head appendages. When the pullet is about to lay, she has a large, bright-red, smooth, glossy comb, and full, smooth wattles (fig. 1, *A*).

When production stops the comb shrinks, becomes dull, dry, and shriveled (fig. 1, *B*). The circulation of the blood in the comb and wattles is diminished with the cessation of egg production, causing them to shrink. As the bird comes back into production after a rest period, the expanding comb begins to assume the shiny stiffness associated with production, and the gloss can be seen plainly.

CONDITION OF VENT

The shape of the vent, as well as its size and condition, changes with egg production. The small, round vent of the pullet enlarges and becomes oval or elliptical in shape during the production period. The dilated, smooth, moist vent of the layer is in marked contrast to the shrunken, puckered, dry vent of the nonlayer.

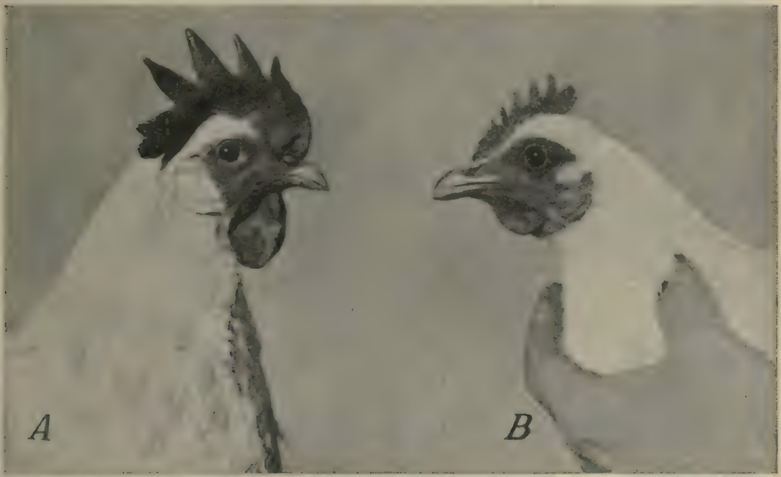

FIGURE 1.—Appearance of comb and wattles of a hen: *A*, In laying condition; and *B*, in nonlaying condition

CONDITION OF PUBIC BONES

The two small bones at the sides of the vent are known as pubic bones. As a fowl comes into laying condition these bones spread apart. The distance between them at this time will be at least 1½ inches, even in small fowls, and may be as much as 3 inches in the larger breeds. A space equal to the width of one finger (about three fourths of an inch) between the pubic bones indicates that the hen is not laying (fig. 2, *A*). A space greater than the width of two fingers usually shows that she is laying (fig. 2, *B*).

Continuous production causes the pubic bones to become thin and pliable. In nonlayers these bones are thick and less flexible. This is caused by the accumulation of fat on the pubic bones during the nonproduction period. During production there is a gradual disappearance of this fat.

CONDITION OF ABDOMEN

The abdomen of a fowl is the rear section of the body and contains most of the digestive and all the reproductive organs. The size of the abdomen, except in an excessively fat hen, is a good indication of whether she is laying. The pullet or the nonlaying hen has a depth of only about two fingers between the pubic bones and the keel as shown in figure 2, *C*. As the pullet comes into laying the abdomen expands because of the enlargement of the oviduct and the intestines (fig. 2, *D*). The expanded abdomen of the layer is soft and pliable and is covered with a thin, smooth skin. In the nonlayer the abdomen tends to be hard and contracted, and the skin feels coarse and thick.

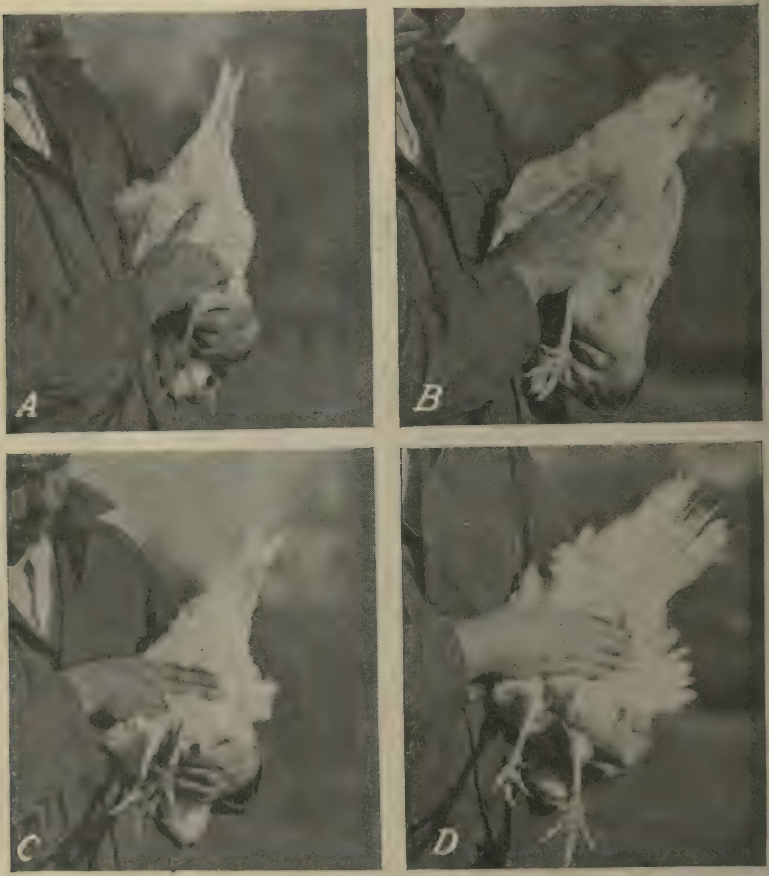

FIGURE 2.—Determining whether a hen is laying by the position of the pubic bones and keel: *A*, Pubic bones close together, indicating that the hen is not laying; *B*, pubic bones far apart, a sign of laying condition; *C*, pubic bones and keel close together, as in a nonlayer; *D*, pubic bones and keel far apart, indicating that the hen is laying.

CONDITION OF LATERAL PROCESSES OF THE STERNUM

The two small bones, one at either side of the body above the rear part of the keel bone or breastbone, are known as the lateral processes of the sternum or sternal processes of the breastbone. These bones are spread apart and forced downward and outward in the laying hen by the increased weight of the internal organs. During heavy production, the sternal processes become very prominent and are softer and more pliable than previously. When the hen stops laying the ends of the processes are closer together, become stiff, and sometimes are so overlaid with fat that it is difficult to locate them.

DETERMINING PERSISTENT PRODUCERS

The selection of hens should not be based on their present laying condition alone. Allowance should also be made for the time of year, length of laying period, and past performance of the individual. The fact that a hen is laying at the time of examination is no proof that she is a persistent layer. Almost any hen will lay heavily during April and May, but if she is not laying in July or August of the year after she was hatched she is likely to be a poor layer.

Although trap nesting is the only practical way to ascertain the exact number of eggs a hen has laid, there are easily observed changes in physical appearance which reveal whether she has been a good layer. Two of the most useful characteristics indicating previous production are changes in pigmentation and the time of year and duration of the molt.

CHANGES IN PIGMENTATION AS RELATED TO PRODUCTION

Pigmentation, as here discussed, refers to the yellow coloring matter in the skin of yellow-skinned breeds. The degree of bleaching of the pigment is a guide in selecting birds that lay well throughout the year.

At the beginning of the laying period a yellow-skinned pullet carries a supply of yellow pigment which can be seen easily in the vent, eye ring, the white of the ear lobe of breeds having normally white ear lobes, and in the beak, shanks, and toes. When egg production begins the yellow pigment in the feed is diverted from the beak, shanks, and other parts to the yolks of the eggs. The pigment in the feed is used in this way as long as egg production continues, and is not deposited in the skin again until production ceases. While the hen is laying, any pigment already present gradually disappears. This process is known as fading or bleaching of the pigment.

Absence of color in yellow-skinned breeds is an indication of previous egg production, and the degree of fading depends on the length of time the supply of pigment has been diverted. The natural order of the bleaching of the different parts of the body most visibly affected is first the vent, then the eye ring and ear lobe, and later the beak and shanks.

BLEACHING OF THE VENT

The color of the skin around the edges of the vent changes rapidly with egg production. When a yellow-skinned pullet begins to lay, the color fades from the vent and may disappear within a few days. Usually, the vent will be entirely bleached within 15 days. A white, pink, or bluish-white vent indicates that a hen is laying, and a yellow vent shows that she is not laying. The bluish-white vent indicates that production has continued for a longer period.

BLEACHING OF THE EYE RING AND EAR LOBE

The bleaching of the eye ring begins very soon after that of the vent and is usually completed in from 2 to 3 weeks after the hen commences to lay. The ear lobe usually loses its yellow tint in from

3 to 4 weeks. In the Leghorn varieties, a bleached ear lobe indicates a slightly longer period of previous production than a bleached vent or eye ring.

BLEACHING OF THE BEAK

The color of the beak fades from the base to the tip, changing from yellow to white in about 6 weeks of continuous egg production. The bleaching of the lower part of the beak or mandible takes place somewhat more rapidly than that of the upper. The bleaching of the lower mandible can be used as a basis for selection when the upper mandible is dark horn in color, as frequently seen in the Barred Plymouth Rock or Rhode Island Red. In the larger breeds the bleaching of the beak may take somewhat longer than in the Leghorn or the Ancona as there is usually a larger supply of body fat present when egg production begins. Even birds of this class, however, will have fully bleached beaks after 2 months of heavy production.

BLEACHING OF THE SHANKS

The bleaching of the shanks takes place much more slowly than the bleaching of the beak and is a good indication of long-time production. The color recedes first from the lower edge of the scales on the front of the shanks; with continued production the yellow color disappears from the rear of the shanks until little pigment is left except in the scales of the hock joint. From 2 to 5 months of continuous egg production are required to bleach the shanks completely.

REAPPEARANCE OF PIGMENT

When a hen stops laying, the yellow color comes back quickly if the right kind of feed is supplied. The color reappears in the same order as that in which it bleaches.

OTHER FACTORS AFFECTING PIGMENTATION

The density or depth of yellow color possessed by a bird before laying begins is influenced by various factors of its environment, health, and individuality. Among these are the feed supply and general management, size and age of the bird, broodiness, thickness of the skin, and individual vitality. The color in the shanks and beak of yellow-skinned fowls may vary from a deep orange yellow to creamy white. Large quantities of green feed and yellow corn in the mash and scratch rations tend to produce highly colored shanks. The extent of yard range as well as the kind of soil affect the supply of green feed, which in turn affects the supply of pigment. The skin of a large, fat bird bleaches out more slowly than that of a small, thin one.

Periods of broodiness also influence pigmentation, since during these periods the yellow color returns to the skin and beak. Persistence in laying has the opposite effect. The 200-egg pullet does not entirely recover her color as a yearling and consequently bleaches out more quickly in her second year of production. Thickness of skin is also a cause of slower bleaching in birds of the larger breeds as well as in individual Leghorns. Low vitality, disease, or rundown condition prevents the accumulation of body fat, a fact which results in bleached shanks. Finally, radical changes in flock management may stop egg production and thus increase pigmentation.

THE MOLT IN RELATION TO PRODUCTION

The time of year and duration of the molt are important points to consider in selecting high-producing hens. The early molter, as previously stated, is usually a poor layer. Furthermore, the hen that takes a long time for molting is a poor layer because her period of production is thereby reduced.

The annual molt takes place during the summer and fall months toward the close of each year of laying. Poor producers frequently stop laying in June or July and begin to drop their feathers. They usually take a long time to complete their molt and as a rule lay no eggs during this period. Extremely early molters are often out of production from 4 to 6 months and usually do not lay until December or January. Late molters, after a rest of only 2 or 3 months, also begin to lay in December or January.

It takes about 6 weeks for a feather to grow out in either a low or a high producer, but the latter grows more feathers at a time, thereby completing the molt more quickly than a low producer. Trap-nest records show that some very high-producing hens take only a 4- or 5-week rest period. Exceptionally persistent birds sometimes have even shorter rest periods, production continuing during August, September, October, and November. Hens of this type usually begin to lay again before the new plumage is fully grown out. A hen must have good health and good body weight to grow feathers and produce eggs at the same time. Special effort, therefore, should be made to keep the laying flock in good flesh during the summer and fall months.

The use of artificial lights to lengthen the hen's working day and the feeding of moist mash may stimulate feed consumption, which tends to keep up body weight and egg production in a flock in which some birds are beginning to molt. If the hens lose weight too rapidly for any reason they may molt earlier than usual. Prime physical condition and maintenance of body weight are essential factors in warding off the molt.

THE ORDER OF MOLTING

When the hen is molting, the feathers on different parts of the body usually are shed in the following order: Head, neck, breast, body, wings, and tail. In some individuals a few tail feathers may be shed before the wing feathers. Shortly after the old feathers are dropped the new ones come in.

After a short period of production, early hatched or early maturing pullets sometimes have a partial molt in the fall of the year in which they were hatched. Neck and tail feathers and 1 or 2 primaries (the stiff, flight feathers seen on the outer part of the wing when it is spread out) may be shed during this molt; but the new primaries do not grow out to full length, and there is a break between the old and the new ones. During this molting period egg production usually stops. To avoid this period of nonproduction, many poultrymen try to keep the very early hatched pullets from going through a partial molt (fig. 3). It is exceedingly difficult to check the partial molt but it may be avoided by hatching at a later date. If, for example, a large proportion of the March-hatched Leghorn pullets go through a partial molt, the hatching date the following year could be postponed until April.

If the selection of layers is made in August or September, toward the close of the first laying year, the condition of the plumage is good evidence as to whether the birds are persistent layers. The plumage of the good layers shows wear and tear from constant visits to the nest and is usually soiled. The early molting hens will have a growth of new feathers. The webs of the new feathers are glossy and bright in contrast to the dry, frayed webs of the old ones. The new quills are large, full, and soft; the quills of the old feathers are small, hard, and almost transparent. A few pinfeathers in the neck may indicate a short molting period, but when shedding extends to the body and wings the molt usually becomes a complete one.

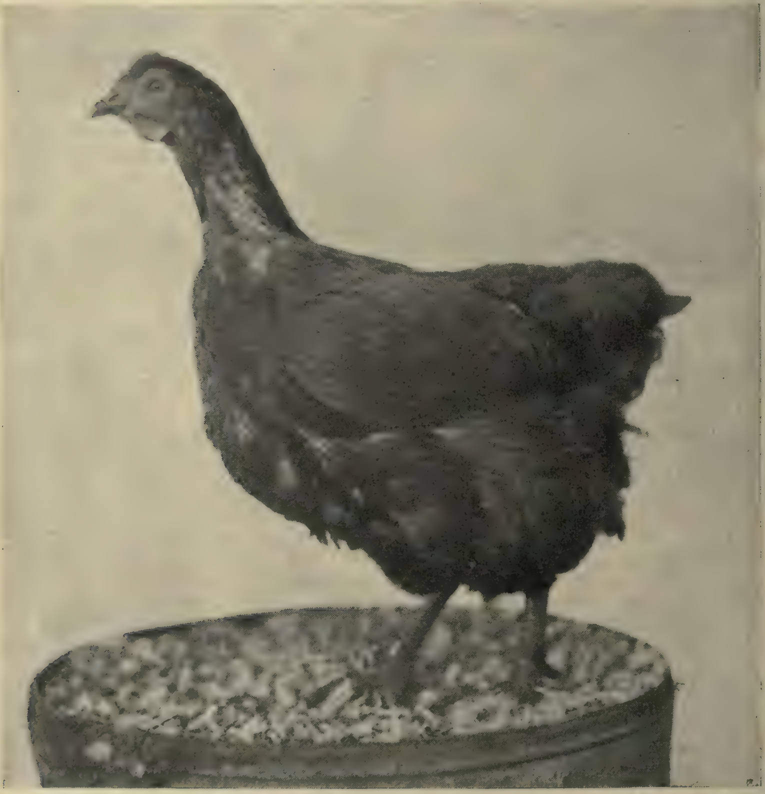

FIGURE 3.—Rhode Island Red pullet showing partial molt on January 1 of her pullet year. Note appearance of new neck feathers and absence of tail. The first year's record of this pullet was 233 eggs; second year, 202 eggs.

A hen usually stops laying when molting the wing feathers but may lay while molting in other parts of the body. However, if the body weight is maintained, exceptionally high-producing hens may continue laying until the wing molt is considerably advanced.

ESTIMATING LENGTH OF MOLTING PERIOD

It is possible to estimate when the molt began by counting the primary feathers in the wing. As already stated, the primary feathers are the stiff flight feathers seen on the outer part of the wing when it is spread out. The secondaries are also large and stiff, but they are found on the inner part of the wing and close to the body of the bird when the wing is folded in its natural position. The primaries are separated from the secondaries by a much shorter feather, known as the axial feather, which grows out at the wing joint.

There are usually 10 primary feathers in each wing, and when the general, or body, molt begins the first primary to be dropped is the inner one next to the axial feather. In the case of the early molter, 2 weeks after the first primary is dropped the second one is shed, and at 2-week intervals each subsequent primary drops. In order to estimate the time elapsing since the molt began, 6 weeks should be allowed for the first mature new primary feather and 2 weeks for each additional full-grown one. Thus a wing having four new full-grown primaries would show that the hen had been molting 12 weeks. If the molt has just begun and none of the primaries are as yet fully grown out, calculation must be made on their present growth. Two thirds of this growth is made during the first 3 weeks, and the other third during the last 3 weeks. A half-grown primary, then, would indicate about 2 weeks of growth.

There is little difficulty in distinguishing the new primary feathers from the old ones. The new feathers are clean and bright with a soft quill and broad outline. The old primaries are much more pointed in shape and are rather worn.

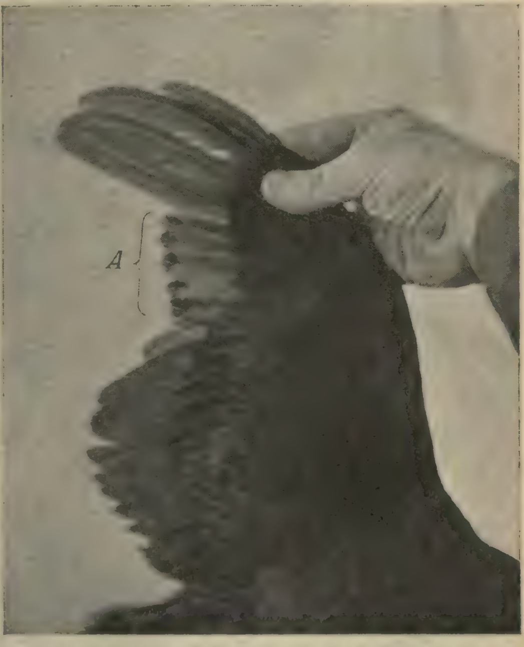

FIGURE 4.—Wing in which five primaries (*A*) are growing out at one time. Multiple production of primary feathers is an indication of rapid molting and good laying ability.

The way in which the wing molt takes place in the low-producing, early molting hen applies in a general way to the high-producing, late-molting hen. The chief difference is in the rapidity of the molt. The low producer and early molter is a much slower molter than the high producer and late molter.

The primaries of the high producer are molted rapidly and in a manner similar to that of the body plumage. Instead of being renewed one at a time, as in the early molter, a group of two or more primaries of the same length may be growing in at the same time (fig. 4). When such a condition is found, all the new feathers of the same length are considered as one in calculating the length of time that has elapsed since molting began. Many high-producing hens do not molt all the primary feathers but continue to carry some of the old ones into the next year. By growing the primaries in groups of two or more or carrying over the old primaries, many high producers materially shorten the time necessary to complete their wing molt.

DEVELOPING A HIGH-LAYING STRAIN THROUGH SELECTION

By adopting a program of selection based on the information already given, the flock owner should be able to increase the efficiency of his flock materially, especially if he eliminates the poor layers from time to time throughout the year. Over a period of years he should develop a permanent selection program that will tend to develop a high-laying strain.

Investigational work at the experiment station at Beltsville has shown that a continuous program of this kind will lead to the development, in a few years, of a high-laying strain, most of the members of which will possess the following four characteristics: (1) Early sexual maturity, (2) good rate of laying, (3) comparatively little broodiness, and (4) persistence of egg production.

EARLINESS OF SEXUAL MATURITY

Since highest prices for eggs are obtained during the fall months, the poultry raiser should strive to hatch his birds early enough to have them laying in September, October, or November. With early maturing stock he should have no difficulty in obtaining good production during the fall months. The best individuals in any flock mature relatively early (at less than 7 months of age) and consequently begin to lay early. These early laying pullets usually lay steadily throughout the year and even late the following fall. Poor individuals, on the other hand, are late-maturing birds that begin to lay late (at from 8 to 9 months of age) and stop early the following summer.

It has been demonstrated at Beltsville that pullets hatched between March 15 and May 8 will lay best throughout their first laying year if they commence in August, September, or October. The data were obtained from flocks of Single-Comb White Leghorns and Rhode Island Reds in which all the birds were allowed to complete their first-year records. The average production of both flocks was approximately 193 eggs per hen. The first year's egg production of each bird included the number of eggs laid in 365 days from the date on which the first egg was laid.

A farmer can detect the early maturing pullets by observing the development of the comb and wattles, the condition of the vent, and the distance between the pubic bones. The early-maturing pullet usually has close-fitting plumage, and there is no excessive fluffiness on the thighs and above the wings (fig. 5). Abundant and loose feathering over the body and abdomen and extremely long, narrow feathers are indications of late maturity and low egg production.

The early maturing birds should be selected and identified by the use of leg bands. For instance, pullets that begin to lay before the first of December may be banded with red celluloid or numbered leg bands. Late-maturing birds may be removed at any time, but if left in the flock they should be marketed when they begin to molt the following June or July. Birds that begin to lay late in the fall usually stop laying early in the summer.

In any group of early maturing birds, there are usually a few individuals considerably below standard weight for the breed. These may be extra early maturing pullets that came into laying before attaining proper size. Some of these small birds may be layers of small eggs and if so should be eliminated in order to increase the average size of eggs from the flock.

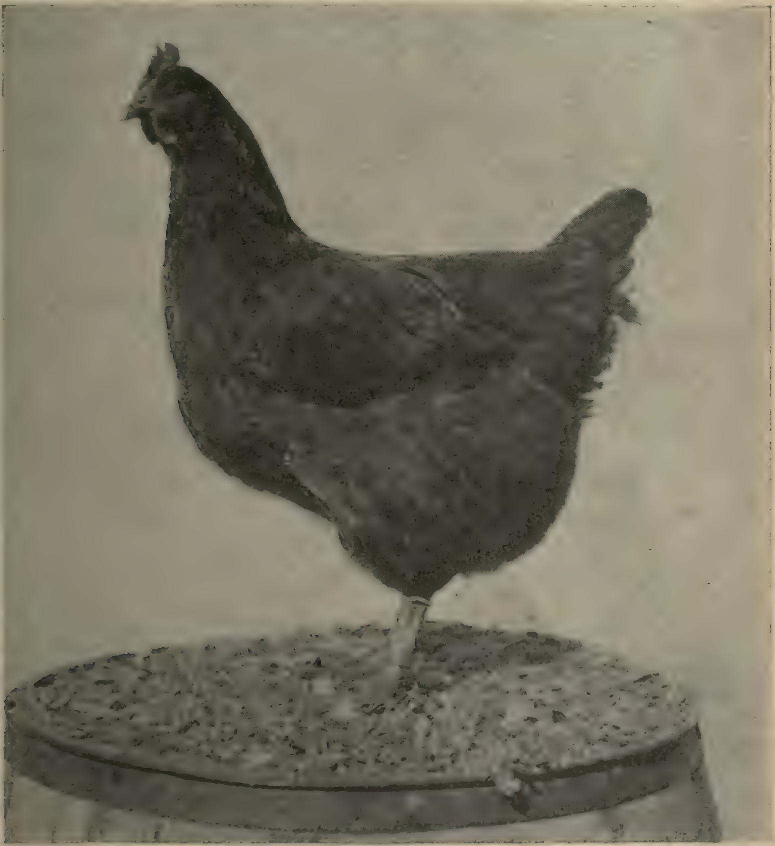

FIGURE 5.—A Rhode Island Red hen which matured early (191 days from hatching date). She laid 232 eggs during her first laying year.

GOOD RATE OF LAYING

Rate or intensity of laying may be defined as the number of eggs laid in a unit of time, such as a week, a month, or the winter or spring period. Another way of expressing rate of laying is by the length of the clutch, which represents continuous production for successive days. Good annual records are made by pullets which lay at a high rate throughout the year.

In the Beltsville flocks of White Leghorn and Rhode Island Red pullets referred to previously, there was a direct relationship between rate of laying and the number of eggs laid during the first year of egg production. The rate of laying was determined by counting the number of eggs laid by each pullet from the time she laid her first egg to March 1, dividing the number by the total number of days in the same period, and multiplying the product by 100. This gives the percentage of the bird's egg production from the time laying began to March 1.

It was found that the higher the rate of laying from the time laying began to March 1, the greater was the first-year egg production. Although the rate of laying in the experimental flocks was determined by the use of trap nests, the flock owner who does not trap-nest his flock can select his best layers from his poorest ones by applying the information already given.

By observing the degree of bleaching of the yellow color in the vent, beak, and shanks it is possible to estimate the steadiness and rate of laying during the winter and spring months. If the birds are examined a few times in the winter and spring, the individuals with yellow color in the beak and the shanks can be detected and eliminated or banded to be marketed later. The most thoroughly bleached beaks and shanks will be found in hens that have been laying steadily at a high rate. These should be retained and banded with white celluloid or with numbered leg bands.

ABSENCE OF BROODINESS

The elimination of broody hens from a flock results in an increase in production. At Beltsville the average production of nonbroody White Leghorns was 194 eggs as compared with 153 eggs for broody ones of the same breed. In a flock of Rhode Island Red hens at the same farm nonbroody hens averaged 205 eggs whereas broody ones averaged 180 eggs.

In any flock it is a simple matter to cull out broody hens by going through the henhouse at night and looking for "cluckers" on the nests. On well-managed poultry farms such birds are promptly confined in broody coops until their broodiness ceases. A broody hen is out of production about 2 weeks on the average even though she is "broken up" at once. Since broodiness is an inherited trait its elimination from breeding flocks may be accomplished by consistently discarding broody individuals.

If, however, the flock owner depends on hens for hatching and brooding chicks it is advisable to save for incubation purposes a few of the hens that have gone broody. But keeping more of these hens than is necessary to incubate the desired numbers of eggs is wasteful. When early chicks or large numbers of chicks are wanted, the incubator is almost a necessity, in which case all broody hens may be marketed at the end of the laying season. Broody hens not desired for incubating eggs should be banded with black celluloid or numbered leg bands and marketed at the proper time.

PERSISTENCE OF EGG PRODUCTION

In order to be most profitable as an egg producer a bird must continue to lay well toward the close of her first laying year. At the experiment station at Beltsville the birds which laid best during August and September, at the end of the first laying year, were the best producers (figs. 6 and 7).

Hens that are laying well in August and September have bleached vents, beaks, and shanks, and usually have worn plumage and show no indications of molt; nonpersistent layers usually have yellow vents, beaks, and shanks, are early molters, and have begun to grow new feathers. Farmers and commercial poultrymen can easily select the most persistent layers by picking out the hens that are laying heavily in August and September and banding them with blue celluloid or numbered leg bands.

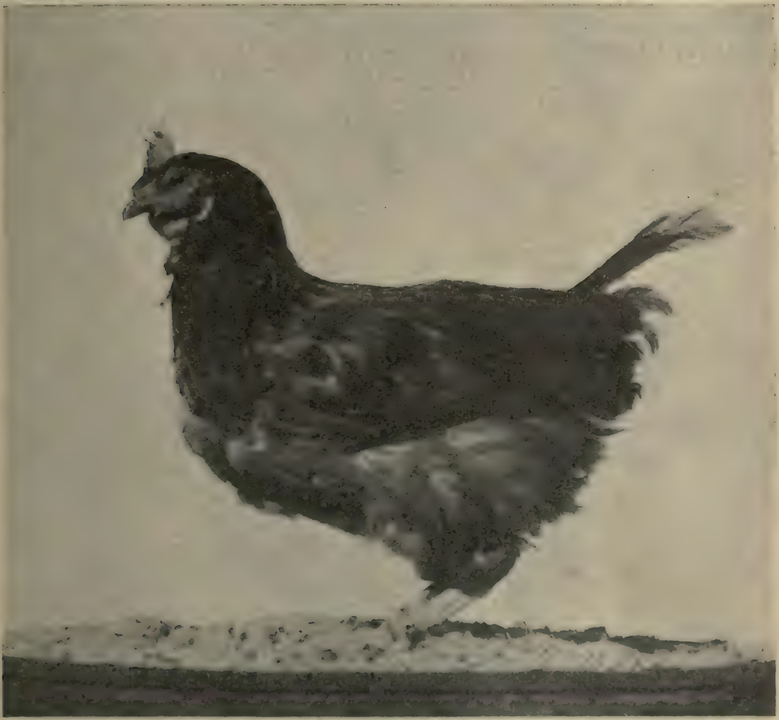

FIGURE 6. Rhode Island Red hen that laid 49 eggs in August and September toward the end of her first laying year. Her record during the first year was 310 eggs, second year 218 eggs, and third year 129 eggs up to June 1. She is shown in full molt in December after 13½ months of steady laying. This hen matured early (172 days), laid at a high rate, was nonbroody, and a persistent layer.

A PRACTICAL SYSTEM OF BANDING

Farmers and poultrymen who do not trap-nest their birds can adopt a very practical method of selecting the best layers from year to year as follows: As previously suggested, use red leg bands for birds that commence laying early, white leg bands for birds that lay at a good rate, black leg bands for birds that go broody, and blue leg bands for birds that are persistent layers. The birds with red, white, and blue bands are the most profitable layers, and the best of them should be kept for future breeding purposes to improve the egg production of the flock from year to year.

HANDLING THE BIRDS

The removal of low-producing hens from a flock may be simplified by the use of a catching hook or net, or by a catching crate as shown on the cover of this bulletin. In a large flock particularly the hook is not always satisfactory because the layers may be badly frightened by the struggles of captured birds. There is also danger of the hook bruising or injuring the leg when a bird tries to escape. A catching crate is a necessary part of the poultryman's equipment for catching and holding the birds when large numbers are being examined. The flock should be confined to the house and driven through the runway exit into the crate as quietly as possible.

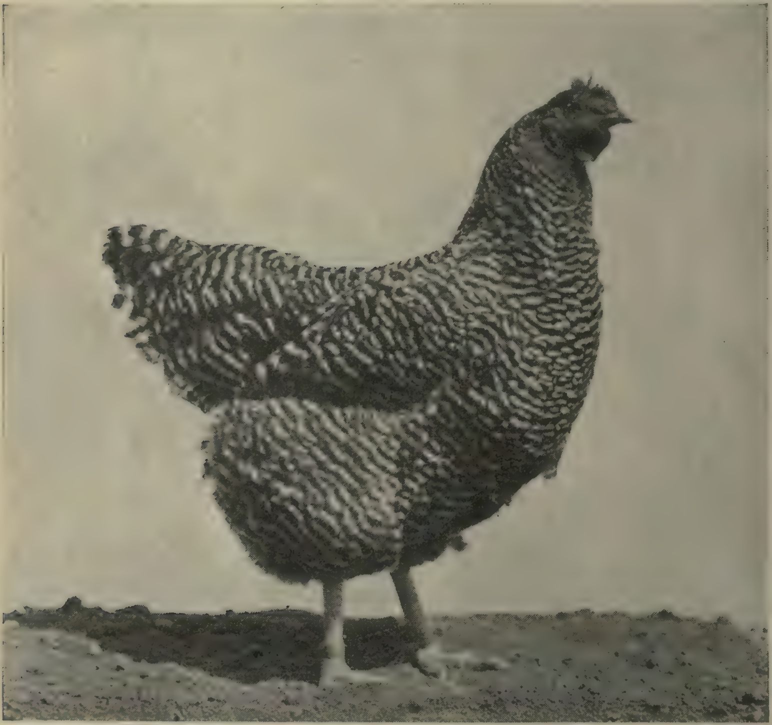

FIGURE 7.—Another high-producing hen. This Barred Plymouth Rock laid 288 eggs during her first laying year, and 204 during the second. She commenced laying relatively early in life, laid at a good rate, was nonbroody, and a persistent producer.

SELECTION CALENDAR AND CHART

June, July, August, and September are the best months for the annual selection of the laying flock because at that time it is easy to distinguish the good from the poor producers. It is highly advantageous, however, for the flock owner to practice selection during every month of the year. Accordingly, the following calendar is offered together with reminders for the selection of both hens and pullets. In the selection chart the characteristics of layers and nonlayers are summarized, together with those of a high-laying strain.

SELECTION CALENDAR

JANUARY	Keep hens that complete their annual molt this month. Band, as good layers, pullets with well-bleached beaks and shanks.
FEBRUARY	Select hatching eggs and baby chicks with great care. Continue to band pullets that have thoroughly bleached beaks and shanks.
MARCH	Market nonlaying hens and pullets that have yellow beaks and shanks. Break up broody hens and leg-band them for marketing later, unless it is necessary to use them for incubation.
APRIL	Continue to market hens and pullets with yellow beaks and shanks, if not laying. Market broody hens that wear a leg band indicating previous broodiness.
MAY	Market old breeders not valuable enough to keep for another year. Watch for early molters; they are usually low producers. Remember that market prices for fowls are usually better at this time than later.
JUNE	Market early molters, thereby reducing feed costs. Try to maintain a 50-percent production during the summer months. Begin annual selection this month.
JULY	Continue marketing molters. Early molters are usually slow molters. Market slow-growing pullets.
AUGUST	Keep hens that are still laying this month. Market those which are well into the molt. Remove weak and unthrifty pullets from the growing flock.
SEPTEMBER	Band, as persistent producers, hens that molt late this month or that have laid throughout the month. Band, as good producers, all pullets that begin laying this month.
OCTOBER	Continue to band hens that begin to molt during this month and those that are still laying. Continue to select and band the early maturing pullets.
NOVEMBER	Make up breeding pens comprising hens that matured early, laid at a good rate, were nonbroody, and showed persistent production. Early hatched pullets that began laying this month will be fair producers. Late-hatched pullets that come into laying this month will be good producers.
DECEMBER	Band, as good layers, pullets that now have bleached beaks and show some bleaching in shanks. Early hatched pullets that begin to lay late this month will be poor layers. Hens that molt this month are persistent layers and may be kept for another year.
ANY MONTH	Remove all birds showing weakness or disease.

SELECTION CHART

Characteristics Identifying Layers and Nonlayers

Character	Condition in a—	
	Layer	Nonlayer
Comb	Large, bright red, smooth, glossy.	Dull, dry, shriveled, scaly.
Face	Bright red	Yellow tint.
Vent	Enlarged, smooth, moist	Shrunken, puckered, dry.
Pubic bones	Thin, pliable, spread apart.	Blunt, rigid, close together.
Abdomen	Expanded, soft, pliable	Contracted, hard, fleshy.
Lateral processes	Prominent, pliable	Hard to find, stiff.
Skin	Soft, loose	Thick, underlaid with fat.

Characteristics Indicating Whether Previous Production Was Continuous or Brief

Character	Condition associated with—	
	Continuous laying	Brief laying
Vent	Bluish white	Yellow tint or flesh color.
Eye ring and ear lobe	White	Tinted with yellow.
Beak	White	Tinted with yellow.
Shanks	White, rather flattened	Yellow, round.
Plumage	Worn, soiled	Not much worn.
Molting	Late, rapid	Early, slow.

Characteristics of a High-Laying Strain

Time of maturity	Laying begins at about 6 months of age in the case of Leghorns and at about 7 months in the case of Rhode Island Reds, Plymouth Rocks, and similar breeds.
Rate of production	Average of 180 or more eggs a year.
Broodiness	Birds are seldom broody.
Persistence of production	Hens are laying well in August and September toward the end of the first laying year or after it is completed.

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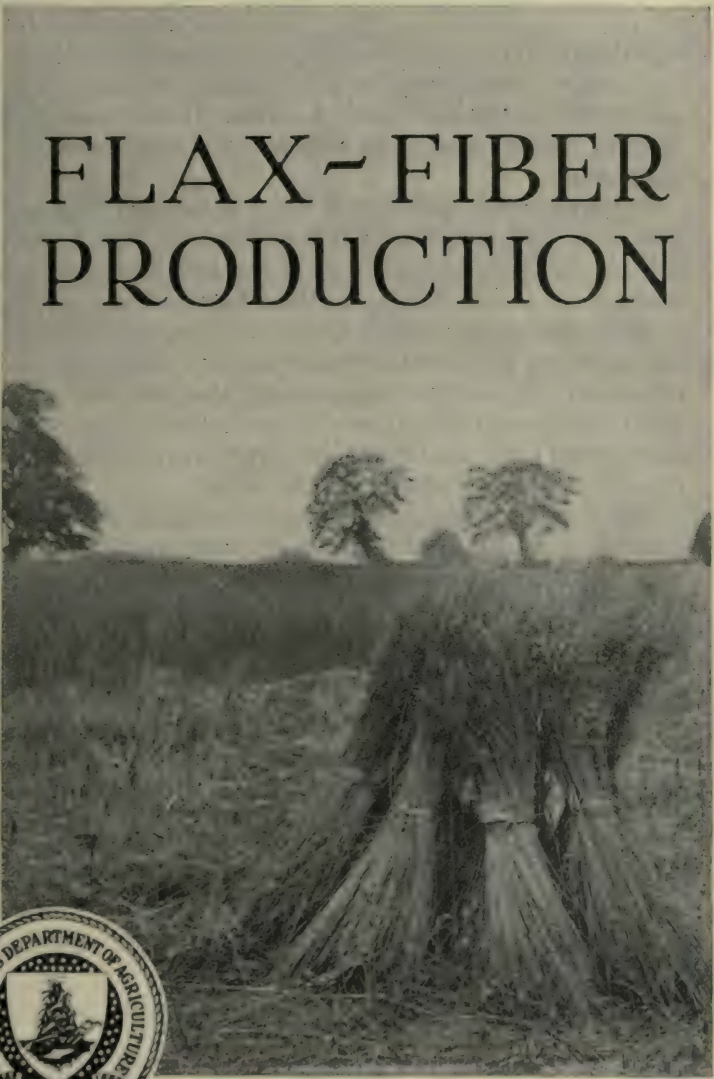
U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1728

FLAX-FIBER PRODUCTION



FIBER FLAX, cultivated from the earliest colonial times to supply fiber for hand spinning in the homes, practically disappeared from American farms when the spinning wheels ceased to be used, before the middle of the last century.

The type of flax cultivated in the Dakotas and adjacent States for the production of linseed does not yield a fiber suitable for spinning, and most of the seed flax is grown where there is not enough moisture for fiber flax. With modern methods of seeding, harvesting, threshing, retting, and scutching much of the former laborious hand labor is eliminated. It has been demonstrated that with the pedigreed varieties of fiber flax now grown, and with reasonable care, fiber of better quality than the average of that imported from Europe may be produced in this country.

This bulletin treats of these details, including the rather exacting requirements of fiber flax in regard to soil and climate. These requirements of soil and especially of climate should be carefully considered before undertaking the cultivation of fiber flax in new areas. With less than 20 flax-spinning mills in the United States, the market for flax is limited.

This bulletin is a revision of and supersedes Farmers' Bulletin 669, Fiber Flax.

Washington, D.C. Issued, July 1934

FLAX-FIBER PRODUCTION

By B. B. Robinson, *assistant plant breeder, Division of Cotton and Other Fiber Crops and Diseases, Bureau of Plant Industry*

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INTRODUCTION

THE PURPOSE of this bulletin is to give information about the best methods for producing flax fiber. Increased yields and fiber of very good quality have been produced on a small scale in experiments, and it is believed that the application of similar methods to commercial field practice may give similar results. There is nothing essentially new in the recommendations, and no particular increase in labor or skill will be required to carry out the work.

Many samples of fiber have been produced in the United States that compared favorably with the best grades of Irish and even Belgian Courtrai flax, but these have been only samples. In recent years flax fiber of excellent quality has been produced in commercial quantities in Oregon, but in many cases there is still room for improvement. It is not probable with American machine methods and the present development of flax-fiber machinery that the very high grades of fiber will be produced, such as are produced by the skilled hand laborers of Europe. It is believed, however, that with better knowledge of the work, avoiding waste efforts and applying labor to better advantage, fiber much better than the present average quality may be produced. The improved varieties of fiber flax will certainly give larger yields and more uniform fiber than may be expected from imported varieties or seed of uncertain origin, but even if improved varieties are grown the proper cultural methods should be employed to realize best results.

HISTORY OF FIBER FLAX IN THE UNITED STATES

Flax was one of the first crops grown by the Cavaliers at Jamestown and by the Pilgrims at Plymouth. In the early colonial days nearly every farmhouse had its spinning wheel, and the women were skilled in the art of spinning fine linen and woolen yarns. It was necessary for the farmers to raise flax, as it was the chief textile used in making their homespun clothes. The farmers deseeded the flax in the field by drawing the seed-bearing ends of the straw through large wire combs, a process called rippling. After deseeding, the straw was mostly dew retted, although sometimes it was water retted. After the straw had been retted, hand brakes were used by the men to break the straw. These brakes were made of heavy wooden slats set edgewise in a frame with other slats crushing the flax straw down between them. In some cases the straw was broken first on an open brake and then on a closed brake. The difference between the two was the closeness of the slats. After it had been broken, the men scutched the fiber with a swingling block and knife to beat out the small pieces of wood from the fiber. This was hard work and much slower than our methods today.

The culture of flax was much encouraged in nearly all of the Colonies north of the Carolinas, and the people became greatly skilled in the different arts of its preparation. Many homes had small hand looms for weaving, and later larger looms took the place of some of the smaller ones. At the close of the eighteenth century there were numerous small scutching mills in the Northeastern States, but the invention of the cotton gin in 1793 and the cheaper production of cotton soon did away with most of the flax-scutching mills. In New York many of these mills continued nearly through the nineteenth century but gradually ceased operation. In Michigan and western Ontario an important fiber-flax growing center was developed, and this industry has never been entirely discontinued. The name of James Livingston will be remembered in connection with the pioneer production of fiber flax in Michigan and western Ontario. At one time he owned and operated 18 scutching mills, 6 in Michigan and 12 in western Ontario. His company also employed 40 to 60 hacklers during the years 1887 to 1910 at Yale, Mich. Although the industry is still in the hands of relatives of James Livingston, it has declined until now less than 1,000 acres of fiber flax are produced annually by his descendants.

CLIMATIC RELATIONS

Without a suitable climate for the production of fiber flax it is useless to expect to be successful even though one selects the best land and seed and follows the best practices in the culture. It is doubtful whether there is another general agricultural crop that responds so well to a favorable climate as fiber flax. Seed flax may be raised under a fairly wide range of conditions, but fiber flax should be planted only in sections where climatic conditions are favorable and where previous experiments or crops have given favorable results. Seed flax is produced largely in North Dakota, South Dakota, Minnesota, Montana, and Wyoming, where the climate is too dry for fiber flax. If grown under dry conditions fiber flax is likely to be short and woody, containing a harsh dry fiber. The fiber-flax plant requires abundant moisture and cool weather during the growing season. Moisture well distributed in many light showers is much better than in downpours. Ideal locations for the production of fiber flax are found around the Great Lakes where the fogs and dews supply moisture in addition to rains. Cool, moist weather from March to June followed by warm, dry weather in July, and the absence of storms that will cause lodging, give excellent climatic conditions for fiber flax in the Willamette Valley in Oregon and in the Puget Sound region in Washington.

Cloudy days are much desired during the growth of the flax, as they help lower the temperature and conserve moisture. After the plant has reached a certain stage in its growth, a hot, dry day may cause it to branch and later produce seed. If the weather does not turn warm the plant continues to grow, not indefinitely but for a longer period. The flax grower as well as the scutching-mill operator should remember that every inch added to the stem below the lowest branches brings more profit. To the farmer it means a greater tonnage of straw and to the millman a longer and higher yield of fiber as well as a straw with a higher percentage of fiber. The fiber of commercial value exists only in the straw from the ground to the lowest branches or beginning of the panicle. The small amount of fiber in the panicle is lost usually in the processes of breaking and scutching, and the root contains no fiber.

Although a cool, moist season is desired during the growing period, warm, dry weather is best for curing the seed after the growth of the stalk as well as for threshing and for drying the straw after retting, especially if water-retting is practiced. Where dew-retting is practiced, there must be sufficient moisture during this period to ret the straw.

In the flax-growing region in Oregon the climate is especially adapted for the production of fiber flax if the seed is planted early. There is usually abundant moisture in March, April, May, and early June, and the dry weather in late June and July cures the flax to a golden yellow, producing a very strong but slightly harsh fiber. The retting is done in tanks, and usually there is excellent weather for drying the retted straw as rains are infrequent from the middle of June to the latter part of September. The climatic conditions for flax-fiber production in the Willamette Valley are believed to be equal to those found in the fiber-flax regions of Europe.

SELECTION OF SOIL

There are two very essential factors in the success of a fiber-flax crop over which the farmer has some control. (1) The selection of a soil type suitable for fiber-flax production, and (2) the planting of the seed sufficiently early to attain a good quality of fiber as well as a high yield. Soil type not only influences the yield of flax but also influences to a very large extent the quality of the fiber in the straw. In European countries the common practice is to keep the flax produced in each small field separate, in order that the quality of the fiber produced in one field may not be mingled with the fiber of a different quality produced in a field of another soil type in the same locality.

It is commonly asserted by experienced flax growers that flax should have a medium-heavy soil for the best results. It will grow on very light soils, but the yields are usually low because of lack of moisture in dry weather and other physical soil relations. A medium-heavy soil that is well drained is ideal for fiber flax. Good drainage is necessary, as the soil must be worked early in the spring, and the young plants will be killed if water stands on the surface after a heavy rain. Light soils and very heavy soils sometimes produce good crops of fiber flax, but they are more uncertain than the medium-heavy soils or silt loams. Light loams underlain with a clay subsoil retaining moisture during droughts have given good results with fiber flax. A sandy soil stores very little moisture and therefore does not supply sufficient moisture in time of drought.

The growth is abundant on muck soils that are common in the flax-growing section near the Great Lakes. The straw yields are extremely high, but the very succulent growth produced is usually associated with large plant cells, and the fiber is coarse and lacks strength. Potash and phosphorous fertilizers may improve the quality as well as increase the yield of flax fiber grown on such soils, but this may make the cost of production too great for reasonable profits.

On heavy soils that are likely to form a hard crust, flax should be planted as early as possible. The early rains will then prevent a crust from forming before the seedlings emerge and begin to grow. After the flax has started it will shade the soil so that it will be less likely to bake and form a crust.

The field selected should not be the poorest on the farm, one that will grow only weeds, but should be one of good fertility. Some scutching-mill superintendents in the United States protect their interests, as well as those of the farmer, by having an agreement before the flax is planted that it will be planted on a specific field known to have given good results with other crops.

PREPARATION OF THE SEED BED

After the first important step of selecting the land, the next step, of equal importance to the success of the crop, is to prepare a good seed bed. Generally, fall-plowed land is used, except perhaps in the Willamette Valley of Oregon. There, if the farmers plow their fields for flax in the fall, the heavy rains that occur during the winter months pack the plowed field, and by spring the soil is possibly in a poorer condition for aeration and hence colder and less productive of bacterial growth than spring-plowed land. Statistics secured in Oregon from numerous flax fields have indicated that early winter or spring plowing has produced greater yields than fall plowing. However, it is advisable in Oregon to plow in January and February, if the weather permits this practice, as fields plowed at that time allow earlier sowing of flaxseed in the spring.

Fall plowing allows the early working of the land in the spring and eliminates the delay that would be occasioned by spring plowing. Fall plowing also destroys many weed seeds and leaves the plowed soil in a better physical condition where freezing and thawing occur during the winter. The land should be thoroughly worked up in the spring to make as fine a seed bed as possible. Disking to begin with, followed by the harrow and a cultipacker, makes a firm seed bed and at the same time leaves the surface somewhat loose. Spring plowing may have to be resorted to when fall plowing is impracticable. In such a case the ground should be worked with equal care, and the bed made as firm as possible. The European farmers are said to make their flax fields as smooth and fine as a garden before planting. This is not altogether folly, since one should remember that in fiber flax the uniform growth of the straw, and not the seed produced on the straw, is the important point, although the seed is a very important source of income. To obtain fiber of high quality and uniformity, it is necessary that all the stems be as nearly equal in diameter and length as possible. This cannot be accomplished if, at planting time, big clods make the ground rough and cause a nonuniform stand of plants.

It is doubtful whether too much emphasis can be placed on the importance of a firm seed bed. A cultipacker or roller will not harm a loose soil and will usually give good results by removing all the air pockets which dry out the soil. While some of the flax roots may penetrate 3 or 4 feet into the soil, the greater number of feeding roots are close to the surface. These must be well established in a firm soil in order to get sufficient moisture and food, especially during droughts. The seed planted in a firm soil will not be planted too deep and will emerge very promptly.

Flax is likely to do very well after corn, if the cultivation of the corn has helped to control the growth of weeds. In the preparation of such land for flax it is not necessary to plow, but the land should be well disked in the fall. If the cultivation of the corn has left ridges, these should be worked down to make a smooth field. In the spring the land should be disked again and then harrowed to make a fine, smooth bed before planting. This method of preparing corn land seems to give good results.

ROTATION

In western Ontario sod land is almost universally selected for growing fiber flax. In eastern Michigan the same practice is commonly adhered to, but there flax often follows a cultivation crop. The cultivation kills the weeds, which is very desirable. In Oregon flax follows a cultivation crop sometimes, but there the mistake has been made of planting flax after flax. Flax should not be planted on the same land oftener than once in 5 or 6 years. If planted more frequently, diseases and weeds become a menace, greatly reducing the yields. Flax wilt, a disease resulting from planting flax after flax, first manifested its importance by lessening greatly the stand and in some cases completely killing all the plants. Today wilt-resistant varieties that partly overcome this condition are known, but wilt is only one of many diseases, and therefore flax should be rotated to avoid wilt and other diseases. Wheat most often follows a flax crop. The flax comes off early in the summer, and then the land may be plowed and prepared for sowing wheat in the fall. Sugar beets and many other crops do well after flax, provided the land is deeply plowed and well cultivated.

Cornfields or bean fields that have been kept free from weeds by cultivation are well suited for flax. In eastern Michigan, land that has been cropped with peas is very desirable. These fields are always fall-plowed or disked in preparation for flax. Flax rarely grows well after wheat, oats, or other small grains.

A rotation should be devised in which flax comes only once in 5 years. The following rotations are offered as some suggestions:

Sod, flax, wheat, corn, oats.
Sod, flax, potatoes, beets, corn.
Corn, flax, wheat, hay, pasture.
Corn, flax, a small grain, clover or alfalfa, clover or alfalfa.

FERTILIZERS AND LIME

It has not been the practice for farmers to use fertilizers for their flax crops. If they are used, they should be applied to the preceding crop, in order that they may be more uniformly mixed with the soil so the flax may have the resulting effect the second year. The danger in applying barnyard manure before planting flax is due largely to the possibility of introducing weeds. Fertilizers, even though they do not contain weed seeds, are seldom applied uniformly over the surface. The result is a streaked field due to an uneven growth of the flax. This is very often seen in grainfields, and while the results might give a good grain yield the straw produced will not be uniform. With fiber flax this nonuniformity of straw in diameter, height, and branching is to be avoided, because the flax stems must be as nearly alike as possible. Nitrogen fertilizers, while likely to increase the tonnage of straw, do not give a corresponding increase in weight of fiber. If nitrogen is applied it has little beneficial effect upon the fiber because of the tendency to make it coarse and weak. It is unwise to attempt to raise flax on poor land by fertilizing heavily. Little or no fertilizer will be needed if a field moderately rich in fertility is selected.

Flax does best on a neutral soil, and, therefore, an application of lime on acid soils may be beneficial. This should not be applied just before planting flax, but before some other crop in the rotation that might benefit from lime. A fresh application of lime to flax will produce a brittle, weak fiber and a straw with a lowered percentage of fiber. Lime applied 2 or 3 years before flax is sown seems to have a beneficial effect and does not lower the quality of the fiber.

Muck or peat soils, although not used to any great extent in growing fiber flax, may require an application of potash or phosphoric acid to produce good fiber, but this may prove too expensive to leave a margin for profit.

It was formerly thought that flax was injurious to the land. This has been sufficiently disproved, as flax takes even less food from the soil than many of our common crops. However, flax land should be plowed deeply for the next crop in order to turn up new soil, as flax obtains most of its plant food near the surface.

PLANTING THE CROP

TIME TO PLANT

The time of planting flax is one of the very important factors in its success. Nowhere in the United States is this more true than in Oregon, where the normal dryness during summer months, beginning with June, stops the growth of the flax, and unless a good growth has been attained before these dry months begin the flax is likely to be a failure and produce only a very short harsh straw. Since the young flax plants will endure a few degrees of frost, it is possible to plant the seed very early. It is also important to plant early because the seedlings are benefited by the early rains and cool spring weather. Cool, moist weather in the spring is ideal for fiber flax. The plants will grow quickly and be well advanced in growth before the warmer and drier weather of June and July arrives. By this time the plant has made its growth and is at a stage to begin to produce seed.

Fiber flax should be one of the first crops planted in the spring. It may be planted at the time of sowing oats or barley. A week's difference in the time of planting will usually make a big difference in the yield of straw and fiber (fig. 1). This is especially so in years when there is a late spring. In most cases the unthreshed straw is sold to the scutching mill, therefore, the heaviest crop possible is desired. If planted early, fiber flax will get a growing start ahead of the weeds and thus better withstand their competition. Late sowings of flax are usually weedier than early sowings. Early-sown flax is more likely to escape injury from flax wilt and rust, since these diseases are more virulent in midsummer or later.

To illustrate the advantages of early planting in Oregon, the yields from the experimental plots at the Oregon Agricultural Experiment Station in 1932 may be cited. Flax was planted first on April 11, which was not considered early, and yielded 3,000 pounds of unthreshed straw per acre. Flax planted 1 week later yielded only 64 percent as much as the first planting; flax planted 2 weeks later yielded only 46 percent as much; and that planted 3 weeks later yielded only 14 percent as much. Table 1 shows the advantages of early planting in Michigan. The figures, however, may be considered as indicative of probable yields in many sections of the United States where fiber flax might be grown.

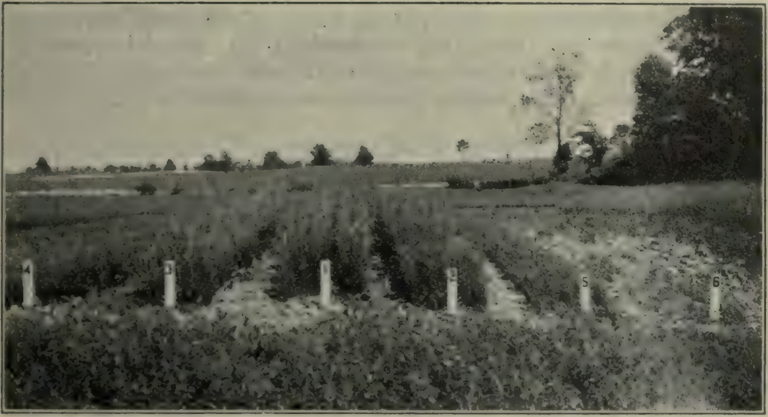

FIGURE 1.—Effects of early and late planting. Plot no. 1 was planted as early as the soil could be well prepared. Plots nos. 2, 3, 4, 5, and 6 were planted about a week apart, in the order named. At full maturity the late-planted fiber flax rarely equals that of the early plantings.

TABLE 1.—*Acre yields of threshed straw and seed of flax planted in different years on different dates at East Lansing, Mich.*[1]

Time of planting	Threshed straw						Seed					
	1926	1927	1928	1929	1931	Average	1926	1927	1928	1929	1931	Average
	Lb.	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*
April, third week	......	2,400	......	......	1,846	......	......	568	......	......	314	......
April, fourth week	......	2,300	2,763	......	1,309	......	......	543	354	......	165	......
May, first week	4,039	2,350	2,481	1,881	1,930	2,536	890	501	293	505	212	480
May, second week	3,975	2,362	2,036	1,904	1,440	2,343	824	534	225	455	147	437
May, third week	2,412	1,600	2,316	2,100	1,143	1,914	537	359	207	318	101	304
May, fourth week	3,341	519	2,301	1,128	1,176	1,693	342	99	166	59	28	139
June, first week	......	......	1,376	1,627	......	......	......		56	51	......	......

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[1] No test was conducted in 1930.

METHODS OF PLANTING

The old method of planting flax was to sow the seed broadcast by hand, and fair results were obtained by a skilled sower. Much of the flax in Europe is still sown in this manner. There, however, the seed bed is usually prepared much better than in the United States, where farming is less intensive. Hand sowing is employed very little in North America today, partly because the art of sowing in this manner has been lost to the present generation but chiefly because of improved machinery. From broadcasting by hand the next step was broadcasting with machines. Many farmers in the United States plant with a broadcasting machine and later cover the seed with a harrow or float. This method is likely to produce an uneven stand, especially on a seed bed not thoroughly prepared, as many of the seeds may be covered too deeply and some not covered at all. Seed covered very deeply emerges in some cases a week or two later than seed germinating near the surface. This makes a nonuniform growth that is very undesirable.

A drill from which the shoes or disks have been removed will distribute the seed more evenly than if the sowing is done by hand. On very well-prepared seed beds, such a drill may be followed by a float or drag, which gives good results. However, the average farmer is so rushed that his seed bed is not usually prepared as well as it should be, and there are clods and depressions in the surface that make the seeds lie at uneven depths if merely scattered upon the surface. Therefore, it is desirable that the seeds be distributed evenly over the field as well as covered to a uniform depth. This work is done best on a firm seed bed with the ordinary grain drill. The drill will distribute the seed evenly and cover it at a uniform depth so that all the plants have an equal start at germination. Most grain drills have feed tubes 7 inches apart, but there are clover and alfalfa drills in which the feed tubes are only 4 inches apart. Such a drill is better, as the seed is more evenly distributed although sown at the same rate per acre. One advantage in drilling is that if the seeds are accidentally placed too deep, the seeds lying side by side have a combined effect upon lifting the soil and pushing their way to the surface. The greatest disadvantage in drilling flax occurs on loose seed beds, where some seeds are likely to be covered too deeply where the drill sinks in the loose seed bed. The seeds should not be sown deeper than 1 inch, and a depth of one fourth to one half an inch is preferable. Figure 2 illustrates the advantage of ½- and 1-inch plantings over 1½- and 2-inch plantings.

RATE OF SEEDING

If flaxseed is broadcast by hand or by machine a little more seed should be sown than if a drill is used, as the distribution is likely to be less uniform and a smaller number of plants may emerge. With a drill, excellent results may be obtained by sowing from 75 to 85 pounds of good seed to the acre. A very common rate is 84 pounds, or 6 pecks, to the acre. The yields may be higher with heavier sowing, but there is danger of the flax lodging, especially the tall-growing varieties that give the best fiber. If the flax lodges badly there is the added difficulty of harvesting, and in all probability it will have to be cut for upholstery tow and sold at a lower price than if sold for spinning fiber. Lodged flax tends to mold in warm, damp weather; mold injures the seed and fiber and lowers the yields. In sections of the country where flax does not often lodge, it may be safe to seed at a little heavier rate, but this must be determined by trial in each section.

SEED

SELECTION

Only seed that has been thoroughly cleaned and thus freed from all light, shriveled, scaly, or diseased seeds should be planted. If the seed is not in this condition when purchased, it should be cleaned by being run through a fanning mill. This is important not only to remove the light seeds but also to remove weed seeds and small particles of straw and chaff that may be present. Rust, a flax disease, is carried on particles of straw, and these should be eliminated. If the seed is clean it will probably germinate well. However, in buying seed it is best to have a guaranty that the germination is of a high percentage.

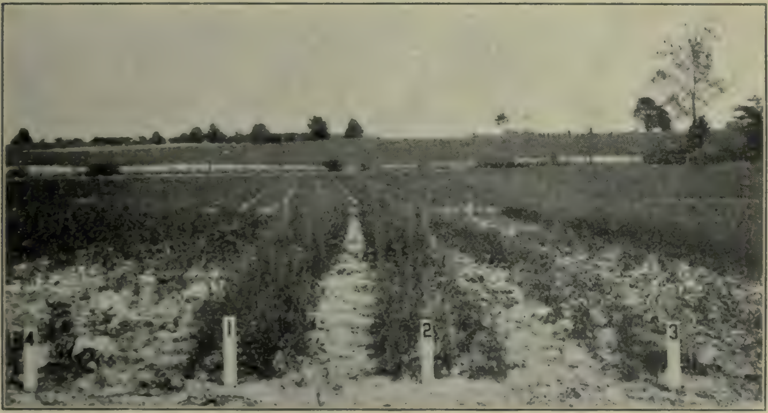

FIGURE 2.—The effect on the stand of planting flaxseed at different depths. The seed was planted ½ inch deep in plot no. 1, 1 inch deep in plot no. 2, 1½ inches deep in plot no. 3, and 2 inches deep in plot no. 4.

Flax for fiber is harvested early and, therefore, often has many immature seeds. If these are not removed in fanning, the rate of germination may be low and the seedlings weak. The germination should be 95 to 100 percent and the seedlings strong and sturdy in appearance. The period of germination is short, usually 3 to 4 days if the weather is warm.

The majority of the farmers plant the seed furnished under contract by the scutching mills. It should be well cleaned at the mills before coming to the farmer, as he seldom has time or facilities for cleaning it properly. Only the heaviest seeds should be saved for planting; those of light and medium weight should be sold to a linseed-oil mill. So far as possible, seed for planting should come from fields known to be free from rust or other diseases.

VARIETIES

In the past most of the seed that has been planted for a fiber crop has been imported from the Netherlands or Russia. This seed has been planted in the United States from 1 to 4 consecutive years, usually only 3, and then new importations have been made. These imported seeds do not represent pure varieties but are designated only by the region from which they come. For example: White Blossom Dutch and Blue Blossom Dutch seed come from the Netherlands; Riga, Pernau Crown, Esthonia, Kostroma, Pskov, and Latvia seed come from Provinces in Russia or countries around the Baltic Sea. In some instances seed of fiber flax goes by the name of the exporting company. In the last few years the United States Department of Agriculture and experiment stations in different parts of the world have been breeding and selecting fiber flax to obtain pure varieties, some of which are now for sale in the United States. These varieties, such as Pinnacle, Lirals, J.W.S., and Texala, give different yields of fiber and seed in different sections of the country. Information as to sources of reliable seed may be obtained from the experiment stations in States where fiber flax is grown. Figure 3 shows a variety test conducted under the supervision of the United States Department of Agriculture at a State experiment station.

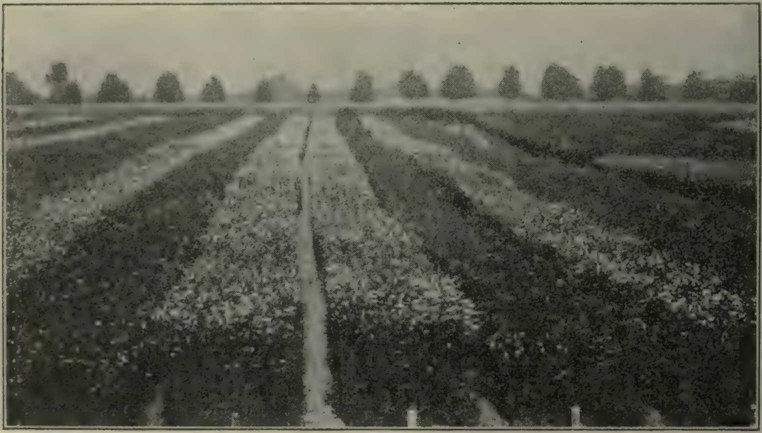

FIGURE 3.—Variety test of fiber flax conducted under the supervision of the United States Department of Agriculture. White-blossom varieties are in full bloom, while the blue-blossom varieties have nearly finished their flowering period. This shows the characteristic lateness of white-blossom flaxes.

With mechanical methods taking the place of hand methods in harvesting and in preparing the fiber, it is of increasing importance to grow improved strains that produce plants of greater uniformity.

Experienced growers of fiber flax will undoubtedly say that seed should be imported each year. This, however, is not necessary if a good variety is obtained. Results have shown repeatedly that the pure varieties of fiber flax adapted to the different sections of the United States will compare very favorably with any imported seed over a number of years. The commercial imported seed may not be of pure strains and may tend to degenerate after 2 or 3 years, after which a new importation will have to be made, but if proper precautions are followed the pure varieties will not deteriorate.

There is always danger, when importing seed from foreign countries, of bringing in plant diseases on the flax seed or on the small particles of flax straw contained in the seed. Because of the danger of bringing in new plant diseases and the fact that good seed may be obtained in this country, it is recommended that importations of foreign seed be avoided.

GROWING SEASON

The growing season for fiber flax is very short, ranging from 85 to 100 days, and the plants mature more quickly if the weather is warm and dry. The seed germinates quickly and usually well. After the young seedlings are an inch above the ground they seem to grow very slowly for 2 to 3 weeks, and then if the weather is favorable they make a more rapid growth until blossoming. During this rapid period of growth the flax requires no care, being treated in the same manner as a grain crop. If weeds are troublesome it may be necessary to pull out those making a large growth. If weeds are removed it should be done while the flax is only a few inches high, as at a later time some of the flax will be trampled down and some pulled up in any attempt to remove weeds.

The plants begin blossoming when they are 55 to 65 days old. The blossoming period is short unless prolonged by cool wet weather. The flowers open early in the morning, and the petals begin to fall about 9 or 10 o'clock, or as soon as the sun becomes hot, but if it is cloudy the petals may remain attached all day. The fields of flax are very pretty at full bloom, a mass of blue or white blossoms, depending upon the variety sown.

The white-blossom varieties are usually 7 to 10 days later in maturing than the blue-blossom varieties. In a locality that has a very short growing season, such as the Upper Peninsula of Michigan, the late-maturing varieties would be objectionable. The white-blossom varieties are grown very little in the United States because they produce a coarse fiber. This is the case with imported white-blossom seed, but it usually produces more seed than the blue-blossom varieties.

IRRIGATION

Fiber flax is not grown under irrigation except in a limited area in Egypt. The surface soil must have good drainage and be well plowed and even on the surface. No water should be added after the plants begin to blossom, as it will only tend to prolong the blossoming period and may cause a second growth, making the fiber of lower quality and the work of scutching more difficult. The soil should have sufficient moisture to germinate the seed, and when the flax begins to grow rapidly moisture is most important. This period will last about 5 to 6 weeks, and during this time, under favorable conditions, an additional growth of 24 to 30 inches may be obtained.

Fiber flax in irrigated fields and in low, moist spots in nonirrigated fields is more susceptible to rust than that in drier fields. The moist places are more favorable for the development of rust. Flax wilt also tends to be more severe in damp fields. On irrigated land or low, damp ground it is especially important to practice rotation and to plant clean seed of disease-resistant varieties.

Fields with uneven surfaces, having low spots that collect water during the irrigation, should be avoided or corrected if possible. The damp areas will tend to prolong the maturing, and the whole field will not be ready to harvest at the same time. Overirrigation should be avoided at all times.

WEEDS AND TRASH

Nearly all contracts with farmers contain a clause permitting the flax-scutching mill to dock the price in case of an excess of dirt, trash, or weeds in the flax when delivered. Dirt is more troublesome in years when the season is wet at harvest time, as small clods of dirt cling to the roots when the flax is pulled. Some of this may be shaken off in pulling, but a small percentage by weight of dirt will go to the scutching mill.

The farmer who plants his flax on clean land has no fear of weeds being troublesome. Prices are rarely docked for flax produced by careful farmers, but the shiftless man who believes that he can produce this cash crop upon his poorest and weediest land often meets with failure. In the production of upholstery tow, weeds are less objectionable, but even for this coarse product it is better to have clean flax straw.

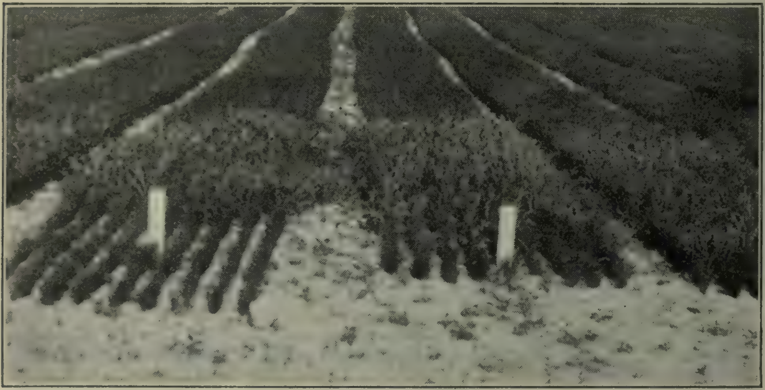

FIGURE 4.—Quackgrass coming up in fiber flax on Government experimental plots. The flax cannot compete with a weed as vigorous as this.

Mechanical pullers, fortunately, do not pull many big weeds but merely strip off the upper leaves. In hand pulling, the weeds unless too numerous may be avoided, but this takes more time than would be necessary to clean the land well before planting. Small areas containing weeds, such as that shown in figure 4, are nearly a complete loss at harvest.

Large weeds, including Canada thistle, dock, mustard, falseflax, dogfennel, French pink, and the twining vines such as dodder, species of morning-glory, bindweed, wild buckwheat, and the grasses, quackgrass, foxtail, barnyard grass, and chess, are especially undesirable. Weed seeds may be present in small amounts that are difficult to fan out of the flax seed. Some of these weed seeds are seeds of French pink, falseflax, foxtail grass, and wild buckwheat.

The best means for fighting weeds in flax is to plant clean seed on weed-free land at an early date. If this is done and if conditions of soil and climate are favorable, the flax will hold its own against weeds.

DISEASES

Flax is subject to a number of diseases, but only 2 or 3 have ever become very widespread in fiber-flax fields of North America. Some of the others have caused serious losses in seed flaxes, but are apparently unknown in some of our oldest fiber-flax regions. This may be partly due to the fact that they have been present but have been overlooked or mistaken for other diseases. That is not so probable in the last 10 or 12 years, since flax diseases have been studied more carefully.

In general, to combat diseases the farmer should plant disease-resistant varieties if obtainable. The seed should be thoroughly cleaned of all trash and light scaly seeds, as these are the principal carriers of disease. All of the diseases of flax have been introduced with seed imported from other countries. There is much less danger in using seed from known sources in the United States. Plant early on land not previously cropped with flax and harvest early.

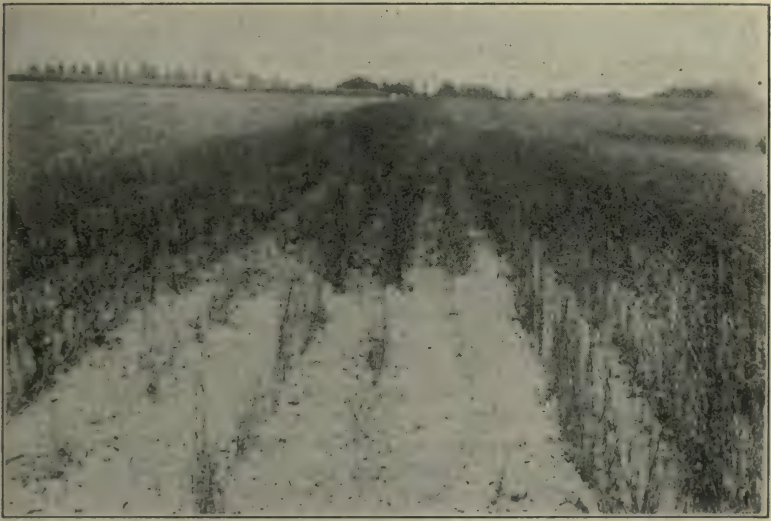

FIGURE 5.—Plot showing resistance and nonresistance to flax wilt. The plants of some varieties are all killed by wilt; in other varieties, nearly all are killed; and in still others, the plants are not affected.

FLAX WILT

Flax wilt has been one of the most destructive diseases, destroying the entire crop in some fields and reducing the yields in other fields. In the last few years this disease has not been very destructive in Michigan and in Oregon, because the flax has been grown on new land or in fields that have not been in flax recently. Tests have indicated that fiber flax is more resistant to wilt than seed flax, but this has not been definitely proved under all conditions. There is, however, always the danger that imported flax seed may produce a crop especially susceptible to wilt, which will result in loss. Several State experiment stations have shown that the plants from imported seed are more susceptible to wilt than the varieties that have been bred and distributed in North America. Figure 5 shows a wilt test conducted upon several varieties, some of which are susceptible to the disease.

The disease is caused by a fungus, *Fusarium lini*, the spores of which remain in the ground and attack the roots. This results in a gradual dying out of the plants. The plants may be affected at any stage in their development, and some plants although attacked by this disease continue to live and produce some seed. The leaves turn yellow beginning at the tips, the plants wilt, the heads bend over, and the plants soon die. The diseased roots are ashen gray, but under the epidermis they are yellow, while the normal color is white. The disease may appear only in spots, but if flax should follow flax the whole field soon would be infected. The best methods for control of the wilt disease consist in growing wilt-resistant varieties and practicing rotations in which flax comes only once in 5 years. The spores of the fungus causing flax wilt are known to remain alive in the ground at least 5 years, and fields on which a flax crop infected with wilt has been produced should not be planted again with flax for a period of at least 10 years. All flax seed used in planting should be thoroughly cleaned before it is sown.

FLAX RUST

Rust of flax, caused by a moldlike fungus, *Melampsora lini*, is one of the oldest known diseases of the flax plant, and it occurs in nearly every region where the flax is grown. It multiplies by means of minute spores, and these must be present with favorable conditions of moisture for flax to become infected. Fiber flax is usually harvested before the disease has advanced to the most destructive stages, and only a few orange-yellow spots of varying sizes may be seen on the leaves and stems. These spots on the stems, if large and deep, injure the fiber so that it breaks at the weakened spots in scutching. This is likely to result not so much in a decreased yield of total fiber as it is in a larger percentage of tow and hence a lower selling price.

In cases where large areas on the stems are infected with rust, sometimes the whole stem, the result is a complete loss of the fiber. However, it is not often that a larger percentage of stems are found in this condition, especially with the improved varieties. An infection of rust is often said to be associated with good flax years and, therefore, looked upon with favor by some, but the relationship of the intensity of the rust and good yields is partly the result of more moisture than in other years.

Orange-yellow roundish pustules, or spots, first appear on the leaves and stems, and later in the season elongated brown to shiny-black spots appear on the stems. The blackish spots seldom appear much before harvest time, and if the flax is harvested early it may escape serious injury. As far as is known at present, no commercial variety of fiber flax is entirely immune to flax rust. Some varieties, however, are much more severely affected than others, and it is advisable to plant the best seed obtainable which is resistant both to rust and wilt. The disease is carried to the field on small bits of stems, leaves, and chaff not cleaned out in the fanning mill. Therefore, special care should be taken in the cleaning. It is best to plant seed from fields known to be free from flax rust.

PASMO

Pasmo, or rust blotch, is a very serious disease first recognized in the United States in 1920. It is caused by a fungus, *Phlyctaena* *linicola*, first discovered in Argentina in 1909. It has been very destructive in limited areas at 1 or 2 local points in fiber-growing sections, but so far it has not become general. The disease appears shortly before harvest. It may be recognized by characteristic yellow to brownish mottled areas upon the stem, leaves, and capsules. The discolored areas grow larger and may eventually cover the whole stem. Green patches between the yellow-brown areas make the disease more easily discernible. Planting seed of varieties resistant to pasmo and harvesting early, in case the disease is present, are recommended as the best methods for controlling the disease. The seed from crops known to be infected with pasmo should not, under any conditions, be used for planting.

CANKER

There are two kinds of canker; one, anthracnose, caused by a fungus, *Colletotrichum linicolum;* and the other, heat canker, caused by high temperatures at the surface of the soil. Neither kind is common in the fiber-growing regions. Anthracnose is recognized by lesions or spots on the leaves and stem, which produce a girdled effect or appearance. Heat canker girdles the young plants at the soil line, causing them to break off. Early seeding on land not likely to crust is the best control for heat canker, while anthracnose may be avoided by planting clean and plump heavy seed.

HARVESTING

TIME

The time of harvesting is an important point in growing fiber flax, but one in regard to which the grower may be helped by the millman. The scutching-mill company that contracts for the flax should be ready to advise the farmer when to harvest, as sometimes it furnishes the machine for harvesting.

Fiber flax is harvested at an earlier stage of maturity than seed flax, but the seed is saved from fiber flax in practically all countries where it is grown except in Ireland. The seed rarely ripens well enough in the continuous cool, moist climate of Ireland to make it worth the extra work of saving it. If harvested too early, the fiber will be very fine and silky but lacking in strength and low in yield. If allowed to become ripe enough for a maximum yield of seed, the fiber will be coarse, harsh, and brittle, with poor spinning qualities.

A good yield of seed may be secured if the flax is harvested when one third to one half of the seed bolls are brown or yellow, with fully developed hard brownish seeds. At this time the stems have usually turned yellow and the leaves have fallen off the stems two thirds of the distance up from the ground. If cut or pulled at this time the immature seeds will ripen on the plant in the shock and the yield will be nearly as large as if they were harvested later. The fiber also will be of much better quality, having retained much of the "nature" or spinning properties that are lost if the plant is permitted to become too ripe.

Short flax and lodged flax, either of which is likely to be used for upholstery tow, should be harvested last, as their value is not as great as that of erect, long-stemmed flax that will produce a high-priced spinning fiber. There are localities where fiber flax is being raised only for upholstery tow, and for this purpose the exact stage of harvesting is less important. Flax seed is an important byproduct in the preparation of upholstery tow; therefore more mature crops are preferred for this purpose, but not those ripe enough for the straw to be brittle.

If there is rainy weather at harvest time the flax is likely to make a very undesirable second growth. This happens after the plant has matured and turned yellow. It will turn green again and begin to blossom a second time. This may cause the plant to branch, which injures the fiber. A second growth in flax will result in fiber of much lower grade for spinning. It is better to harvest at once if second growth starts. This growth will add no weight to the final amount of fiber obtained, as it is a growth of seeding branches and wood. The plants become more woody and are much more difficult to scutch.

METHODS

HAND PULLING

Pulling by hand is still practiced in most of the fiber-flax-growing sections of Europe. Labor there is cheap, and the men, women, and children are accustomed to the work. In western Ontario most of the Canadian fiber flax is grown near an Indian reservation, and the Indians do the pulling. The Indians camp right in the field, and the women and children help in the pulling.

A few years ago the fiber flax in the United States was pulled by hand, but now it is difficult to get men to do this kind of work. It is indeed tiresome work the first day, but one quickly becomes accustomed to it. The amount pulled in 1 day depends upon the ability of the worker, but varies from one-eighth to one-fourth of an acre per day. In 1928 Oregon flax growers paid as high as $25 per acre for pulling flax by hand, but even at this price, it is difficult to get men to do it. However, in 1932, owing to the scarcity of work it was possible to find many laborers who were willing to pull flax by hand in Oregon for $10 per acre, and flax was pulled by machines under contract for $4 per ton. If flax-pulling has to be done by hand it is very unlikely that an extensive fiber-flax industry can be developed in the United States.

MACHINE PULLING

Many machines for pulling fiber flax have been devised in the last 20 years. A dozen different kinds have been built, and some of them have been used in the fields. The machines have steadily improved until now there are 1 or 2 on the market that do pull flax fairly well (figs. 6 and 7). Still further improvements are necessary for really satisfactory work. In 1923 the Vessot pulling machine was introduced into Oregon, and the number of machines has been increased each year. These machines have been improved each year, and the price has decreased. There have been breakdowns and delays in pulling, owing to imperfections in the machines, but in the end the machines have pulled practically the entire flax acreage in Oregon. There are 1 or 2 other flax-pulling machines on the market that have not been tried out in the United States. Possibly in the future these foreign pulling machines, which are cheaper in price and much simpler in construction and operation, may be tried out in the United States.

MOWING

If upholstery tow is being produced, mowing offers an excellent and inexpensive method for harvesting the crop. The flax is mowed down at the rate of 4 to 6 acres per day and allowed to cure on the ground several days before being hauled to the mill. Fibrous flax plants are tougher and harder to cut than grass, and it is important to keep the knives sharp and the bearings of the machines well oiled. The knives should be replaced by sharp ones every 3 hours or even oftener if the flax is overripe and some of it dead,

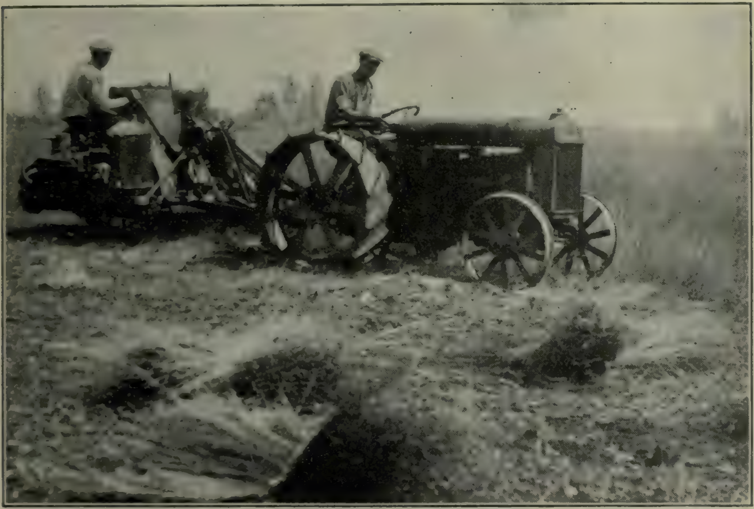

FIGURE 6.—One type of flax puller in operation. The pulling device on this machine is driven by a gasoline motor that is attached to the side of the machine.

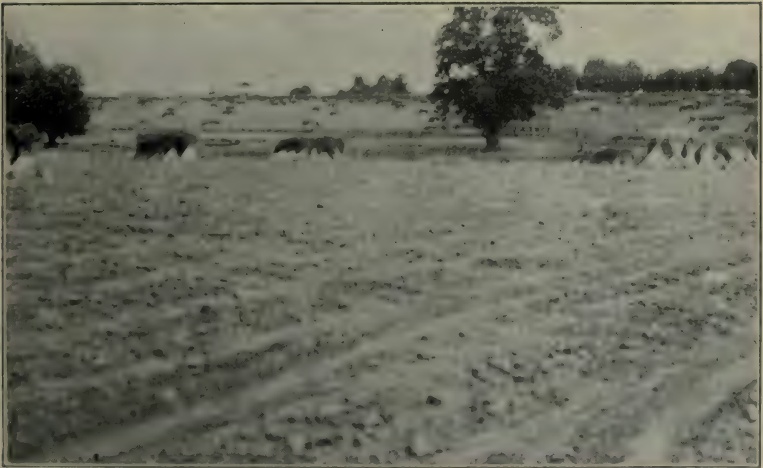

FIGURE 7.—Flax fields in Oregon that were harvested by a machine puller. The pullers, when working well, get all the flax, as is shown by the cleanness of the field.

because in this condition the flax is very tough. There is occasional trouble from the mower becoming gummy and hard to operate. This gum may be removed readily with kerosene or gasoline. A type of mower used extensively in eastern Michigan for harvesting flax for upholstering tow is shown in figure 8.

THRESHING

In the production of upholstery tow the threshing offers no problem, since the machine making the tow also does the threshing, and the seed is cleaned afterward by a fanning mill. For the production of line fiber, flax is threshed before it is retted. In some cases the flax is retted with the seed still on the straw. This results in a partial loss of the seed or in most cases where this is practiced, as in Ireland, there may be very little seed worth saving. The common method of threshing fiber flax, both in the United States and in western Europe, consists in passing the seed-bearing portion of the straw 3 to 5 times between smooth revolving rollers pressed together by springs (fig. 9). The straw is not injured, and the seed bolls which are crushed, fall off. This method, while effective upon small bundles of hand-pulled flax, involves much hand labor in untying the large bundles of machine-pulled flax before they are threshed, and retying them after threshing.

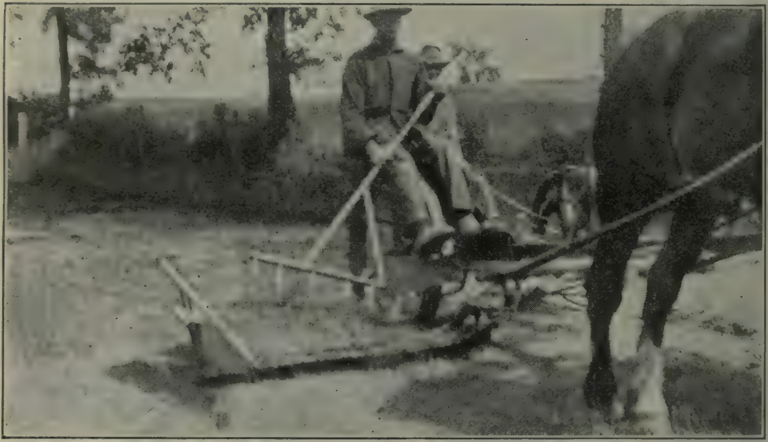

FIGURE 8.—Type of mower best adapted for cutting flax for upholstery tow. One man drives the team and the second man rakes the cut flax off from a platform in small bunches.

There are machines in Europe designed to thresh flax with less hand labor, but they are still more or less in the experimental stages and are not used in many factories. Their practical application has not been demonstrated in North America. The straw must not be broken, as it would be in passing through a grain separator, because uniform retting would then be impossible and the fiber produced would be suitable only for upholstery tow.

If dew retting is practiced the flax may be moved from the shock to the threshing machine, and after threshing the straw is spread on a field to ret. Where tank retting is practiced the flax may be stacked as shown in figure 10 or, better, stored under sheds as shown in figure

11. It may then be threshed as fast as the straw is needed to fill the retting tanks or threshed and stored again to await retting. The retted straw, when dried, should be put under a shed until scutching time.

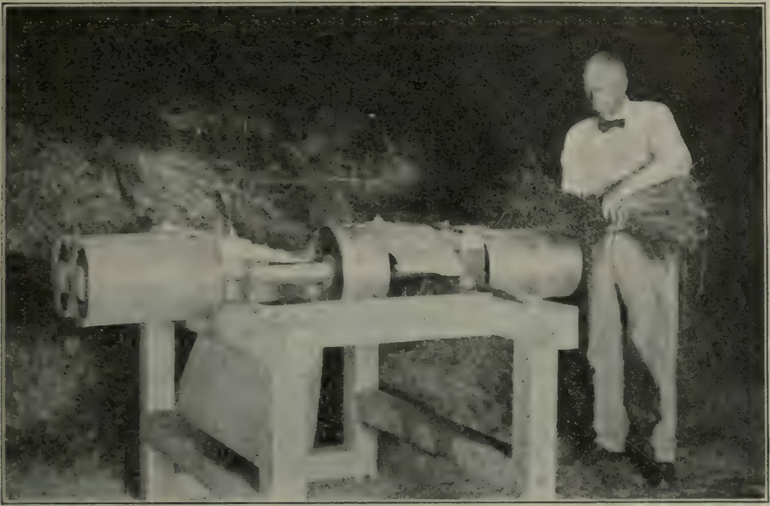

FIGURE 9.—Fiber-flax threshing machine. The bolls, or heads, are passed a few times between the revolving-belt pulleys, which are pressed together, crushing the seed bolls.

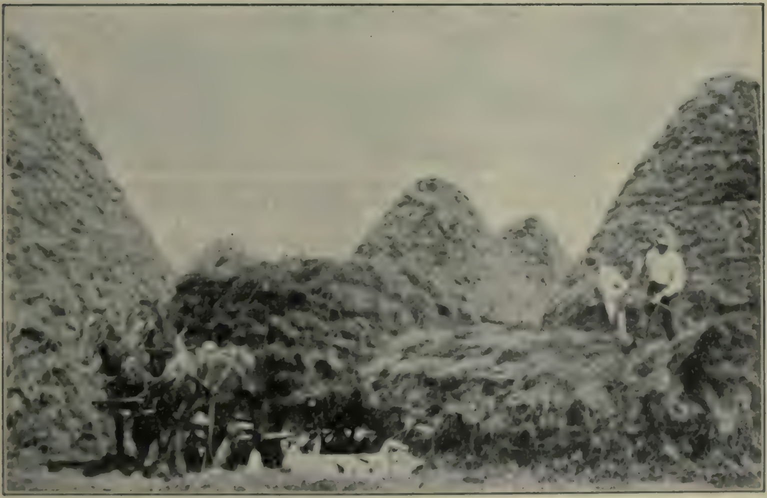

FIGURE 10.—Fiber flax, after being cured in shocks in the field, is drawn to the scutching mill and stacked until it can be threshed and retted.

YIELD

The yield per acre of fiber flax may be stated in several different ways. For example, unthreshed straw, threshed straw, line and tow fiber, and seed. If the fiber flax is being grown entirely for green or upholstering tow, it is customary to mow the flax, and this flax (when well cured) will yield about 1½ tons per acre. Often only the poorest fiber-flax fields, which will not produce a good spinning fiber, are mowed and used for the production of upholstering tow, and in such cases the yield of mowed, unthreshed straw will probably average less than 1½ tons per acre.

Most of the fiber flax used for the production of fiber for spinning is pulled either by hand or by machine, bound in bundles, cured in shocks, and drawn from the shock directly to the scutching mill. The yield of flax in this form ranges from 1 to 3½ tons per acre, averaging about 1¾ tons. Under favorable conditions and on well-managed farms the yield of pulled, unthreshed straw may reach 3 tons or more per acre.

The yield of seed from different varieties of fiber flax varies, in some instances nearly equaling the yield from seed flax. Average yields, when the seed has been sown at the rate of 70 to 85 pounds per acre for fiber production, range from 5 to 10 bushels per acre. Thinner seeding gives a higher yield of seed and lower yield of fiber. The yield of seed will also vary with the variety and with conditions of soil and climate. Generally the flaxes yielding the most seed yield the least fiber.

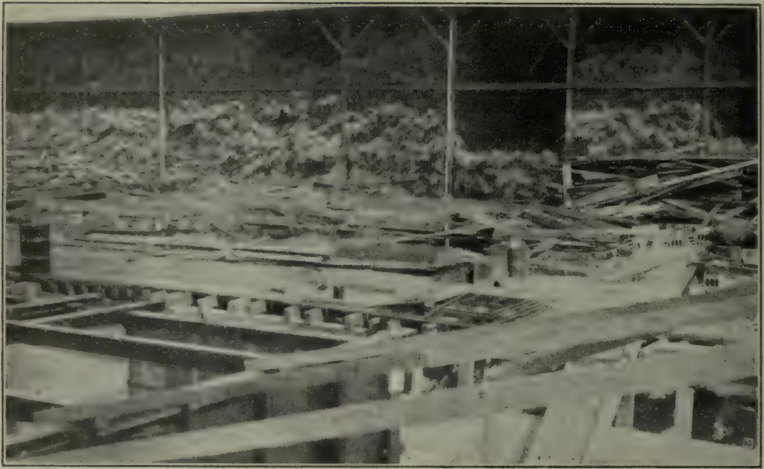

FIGURE 11.—Large, open, inexpensive sheds are used for storing pulled flax. It remains there until taken to the retting tanks. Single sheds are built to hold 500 to 600 tons of flax straw.

The yield of fiber flax in different stages, as produced in the United States, may be stated roughly as follows:

Pulled flax in bundles, unthreshed, as usually sold by the growers, 1 to 3½ tons per acre, averaging about 1¾ tons.

Threshed flax, before it is retted, after losing 33 to 35 percent of seeds and chaff, about 1⅕ tons.

Retted straw, after it has been dried and has lost about 16 percent in retting, 1 ton.

Scutched fiber, including tow, after losing about 80 percent in scutching, 400 pounds.

Seed varying from 5 to 10 bushels per acre averaging about 7½ bushels.

PRODUCTION OF UPHOLSTERY TOW

In the production of upholstery tow the fiber-flax straw is not retted. The unretted flax straw is crushed so that the fiber separates from the woody part of the stem. The fiber produced in this manner is used in upholstered furniture, car seats, and automobiles, and is known as upholstery or green tow to distinguish it from the tow prepared for spinning. This industry seems to pay fair returns. In unfavorable years when all fiber flax is short, the companies ordinarily producing fiber for spinning cut a large proportion of their flax for upholstery tow. This increases greatly the amount of green tow offered for sale and lowers the price of all upholstery tow. In such a year a company that usually manufactures only upholstery tow from fiber flax has greater competition in a market oversupplied with this high-grade tow. The mills making green tow from fiber flax must always compete with the mills in Minnesota making tow from seed-flax straw, but this competition is not very great because of the difference in quality between the two products.

For several years after the World War fiber-flax upholstery tow commanded a price nearly twice as great as the western seed-flax tow. However, during the depression years of 1932 and 1933 fiber-flax upholstery tow was offered for sale on a much narrower margin over seed-flax tow than formerly.

This industry, while not extensive, is probably sufficient to supply the limited demand for good-quality tow. It requires very little hand labor, and no retting, scutching, nor threshing of the straw by expensive methods. Weeds and diseased straw, while objectionable, do not cause as much loss in upholstery tow as they do in fiber for spinning.

In common practice a company operating an upholstery-tow mill furnishes the seed to the farmer who does the planting. At harvest time the farmer cuts the flax with a machine, also furnished by the company, and after a few days hauls the cured straw to the mill, where he receives cash for his crop. It is purely a cash crop for the grower, and one of the earliest cash crops produced. It requires little outlay of money, but it does not often bring large profits.

Usually 3 tons of flax straw are made into 1 ton of upholstering material. In 1932 and 1933, owing to the low price that manufacturers were willing to pay for a high grade of upholstery tow, it was somewhat common to find mills making 1 ton of upholstery tow from 2 tons of straw.

The woody shives that are separated from the tow, or fiber, may be used for fuel. The mill, besides selling the green tow, makes a profit from the seed as a byproduct. The demand for good fiber-flax green tow, while not large, might be increased through a more thorough understanding of its use and value. In some cases it might be substituted for more expensive packings of wool and hair.

PREPARATION OF SPINNING FIBER

The farmer, or grower of fiber flax, delivers the straw at the scutching mill after it has dried in shocks in the field. The processes of preparing the fiber from the unthreshed straw requires special apparatus and must be carried on by men having skill and experience in this particular work in order to produce uniform fiber acceptable to flax spinners.

RETTING

The word "ret" means rot. Retting, therefore, is simply a process which dissolves certain gums in the plant that bind the fibers to the wood and destroys the thin-walled tissues surrounding the fibers. This may be brought about by bacterial action or by chemical changes. The bacteria that cause the retting or rotting of the straw are common soil bacteria and are present on the straw when harvested. They are present in all soils, so that one need not worry for fear the flax will not ret because of lack of bacteria. At present all flax produced in commercial quantities is retted by bacterial action. Two methods are practiced in North America, namely, dew-retting and tank- or water-retting.

In dew-retting, flax is spread on the ground where it has been grown or, preferably, on grass or meadows, where it is retted by molds and bacterial action induced by frequent rains or dews. Retting is usually completed in from 1 to 3 weeks, depending upon the weather. In moist, warm weather the action is more rapid and may require only a week or 10 days. In cooler or drier weather the retting is slower and may require a month.

In dew-retting it is important to have the straw spread evenly and very thinly on the ground, as the dew should get to all of the straw to secure uniformity. To facilitate uniform retting, the straw is sometimes turned during retting. This involves more labor and expense, but it may be well worth while if the straw is long and of good quality. Dew-retting is entirely dependent upon the weather and, therefore, uncertain. If continued wet weather prevents lifting the straw in the field at the proper time, it becomes overretted and of little value. In nearly all cases the product is not uniform, and the fiber must be sold at a price lower than that of water-retted flax.

Water-retting, or tank-retting, seems to give the best results under American conditions. This is also true under European conditions, as practically all of the better grades of fiber are produced by water-retting. The initial cost of building the tanks may be large, but the retting is then under control and not dependent upon the weather. Fiber of good quality and more uniform in color and strength may be produced with greater certainty.

Water- or tank-retting consists in placing the straw in wooden or concrete tanks which are then filled with water. The ret here is accomplished in 6 to 8 days if the water is free from impurities and kept at 80° F., which is the temperature best suited for retting. Sometimes the retting will require a greater length of time, owing to the fact that the straw may be particularly fine or small in diameter, and it may have been produced in a dry season and be very hard or woody, and so require more retting and more care in scutching to separate the fiber from the straw. All the straw in a tank is subject to the same amount of retting, due to the penetration of the water, and the water may be drained off from the tank as soon as the ret has reached a desired stage. The best retting is done where the water is kept under controlled conditions of temperature and circulation. The heat necessary for warming the water may be furnished by burning the shives obtained in scutching.

The water in the tank should be kept circulating to facilitate more even distribution of temperature and bacteria and cause a uniform ret. The circulation of the water is not begun until after the first day, and this is said to allow the retting to start. When the circulation is started, water at the right temperature is forced into the tank at the bottom, causing an overflow at the top. The water that runs off at the top may or may not be again forced into the tank. It is best not to put too much of the old water back unless it is purified, since it contains waste materials that slow up the ret. In most warm-water retting factories, the water in the tank is circulated to a slight degree. The amount of fresh water that is added during the ret will govern to some extent the degree of acidity, the speed of the ret, and the harshness of the fiber. In retting tanks, where the fresh water is added slowly so that all the water in the tank is replaced once in 24 hours, the fiber is likely to be harsh but well bleached. It is more common to replace the old retting water only once during the entire ret, although possibly under certain conditions a tank will often become what is termed sour and the retting will not proceed any further until all the water has been discharged and a new supply added. Retting tanks built on the bank of a small stream are shown in figure 12.

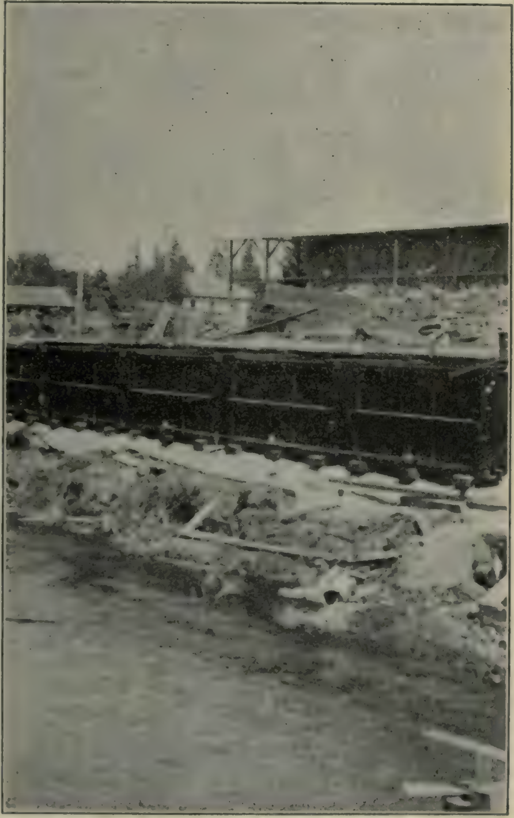

FIGURE 12.—Retting tanks built on the bank of a small stream that furnishes the water. A flax storage shed may be seen in the background.

Numerous quick retting processes have been suggested, but thus far none of them have been efficient enough to be adopted in place of dew-retting and water-retting. The element of time in itself in these established methods is inexpensive, and they usually require less actual work than the quick retting processes advocated. Furthermore, the fiber produced by the quick retting processes has rarely met with the approval of flax spinners.

DRYING AFTER RETTING

Dew-retted flax is "lifted" in the field, taken up, and bound in bundles when the bark containing the fiber separates readily from the woody inner part of the straw. The bundles of retted straw are hauled to the scutching mill. If rainy weather should set in, there is danger of some straw overretting before all of it can be lifted. Water-retted flax must be taken out of the tank and spread on the ground or "wigwamed" in a field to dry. Wigwaming consists in setting up each wet bundle of retted straw with the butt ends resting on the ground and these spread out so as to allow free circulation of air (fig. 13). In Oregon, where the straw is tank-retted and then wigwamed in the field, there is usually favorable weather during the summer months to dry the straw. The straw when wigwamed has the advantage that it is off the ground in case of unfavorable weather, and requires only a few hours of sunshine to dry. If rains occur during the retting season the wigwams should be made from small bundles in order to hasten drying. If damp weather is experienced only in the fall, then the area covered per ton of straw in the fall should be increased. Slow drying in warm weather may cause moldy straw.

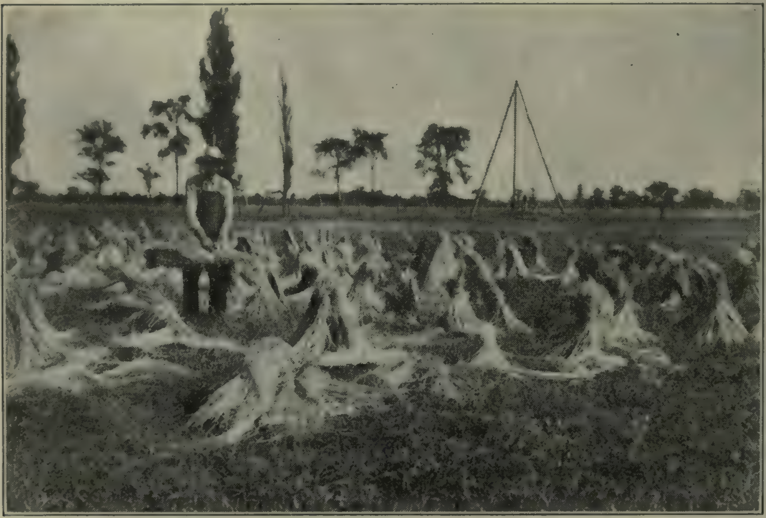

FIGURE 13.—Fiber-flax straw, after being retted in water, is taken from the tanks and set up in "wigwams" to dry.

Drying is usually accomplished with little difficulty except in the fall, when cool weather and rains interfere with and finally stop the work. In order to control drying, several methods have been devised to dry the straw artificially. At present, to the writer's knowledge, none of these has proved successful enough to do away with air drying in the field. An efficient artificial drying method would make it possible to dry the straw all the year round, and retting would not have to be stopped at the beginning of cold or damp weather. Excessive heat in drying flax straw is thought to drive off the oil and cause a loss of "nature", without which the fiber has poor spinning quality.

BREAKING AND SCUTCHING

Breaking is the process that follows retting in extracting the fiber from the stem. It consists essentially in breaking the woody portions of the straw into fine pieces, called shives, and at the same time breaking these shives away from the fiber or loosening them so that they may be beaten off in the next process, called scutching. In the

United States and in western Europe breaking is usually accomplished by passing retted dry straw, a handful at a time, between fluted rollers. The fiber is strong and flexible enough to resist the breaking and comes through as a long unbroken fiber.

In the preparation of spinning tow on a large scale the retted straw is passed through a series of fluted rollers followed by a beating cylinder and usually a shaking device. The straw is so broken and shaken that the fiber comes out free from wood or shives. A few of the newer flax-tow machines are devised to produce a scutching action upon the tow. Scutched or "targed" tow for spinning is prepared by holding the fiber from tangled stalks against the revolving blades of a scutching wheel.

In the production of line fiber, separate machines are used for breaking and scutching. The straw is kept straight at all times and is first put through a small break and then scutched by hand or by machine. Hand-scutching is very expensive work in the United States. This work requires a skill that can be acquired only by experience, and in the United States it is difficult to find men having the necessary skill.

Several small combined breaking and scutching machines have been devised in recent years. They require less hand skill than the scutching wheels, and some of them produce well-cleaned fiber with little waste. Thus far the capacities of the machines have not been much greater than the capacity of the brake and scutching wheel. Improvements are being made in the machines, and with increasing efficiency and lower prices they may take the place of hand-scutching, as the hackling machines in the spinning mills have taken the place of hand-hackling in the scutching mills. Only in the past few years have large scutching machines been invented, which reduce the cost of scutching enough so that this process can be carried on successfully in the United States with our high prices for labor. These improvements came after the World War. These turbine-type scutching machines were first introduced into this country in 1928. Previous to the invention of these turbine-type scutching machines, one man could clean on a scutching wheel from 65 to 75 pounds of flax fiber per day. These new machines increased production per man approximately 200 to 350 percent and produced a fiber of much better quality. The better quality is mainly due to the fact that the amount of waste is not so great and that the next process of hackling, which is carried on in a spinning mill, does not cause so great a loss as hand- or wheel-scutching flax formerly entailed.

MARKETS

The grower of fiber flax in the United States sells the product at the scutching mill in the form of bundles of unthreshed straw, drawn from the shocks in the field. Flax to be used for upholstering tow is delivered at the scutching or tow mills loose like hay. These products are of too little value as compared with their bulk to be delivered beyond a short trucking distance. A hauling distance of 25 to 30 miles over paved roads is regarded as about the maximum that permits reasonable profits.

No quotations of flax fiber are published in the United States. The prices vary, depending upon the supply and demand. The range of prices for the fiber is governed almost entirely by the Russian and Belgian prices.

There are 17 flax-spinning mills in the United States: 14 in New England, New York, and New Jersey, and 3 on the Pacific coast. These mills use from 4,000 to 8,000 tons of flax fiber each year. The quantities produced in this country, 150 to 350 tons per annum, are relatively insignificant as compared with the total supplies required. Most of the flax fiber used in the American spinning mills is produced in Russia, the Baltic countries, or Belgium. The flax-spinning mills on the Pacific coast use practically all of the fiber produced in Oregon and import some of certain grades for mixing to make standard uniform yarns. A modern spinning mill producing yarns or twines for the general market cannot depend on a single source of supply for fiber.

MANUFACTURED PRODUCTS

Flax fiber is spun into linen yarns of various degrees of fineness from 8 lea, 2,400 yards per pound, to 120 lea, 36,000 yards per pound. In the spinning mills of this country linen yarns are rarely spun finer than 40 lea, 12,000 yards per pound.

The straight-scutched fiber is hackled in the spinning mills mostly by large hackling machines, which comb out all of the short and tangled fibers and shives. The hackled or dressed fiber is further combed repeatedly by being passed through several drawing frames before it reaches the spinning machine, which twists it into yarn. It is spun either dry or wet, depending on the kind of yarn desired. In wet-spinning, the strand or roving of fiber passes through a trough of hot water just before reaching the spindle. The finest yarns are wet-spun.

Flax tow goes through a carding machine instead of being hackled, and is carded into strands of parallel fibers before being spun into yarn. Tow cannot be spun into yarns as fine as those made of line fiber.

Linen yarns are doubled and twisted into shoe thread, tailor's thread, sewing thread, tying twines, carpet warp, bookbinder's twines, fishing lines, twines for fishing nets, and thread for laces. The yarn is woven into crash, toweling, buckram, sheeting, pillowcases, dress linens, handkerchiefs, fire hose, airplane wings, and plain or damask tablecloths and napkins.

Special skill is required for spinning fine linen yarns, and also for weaving the fine yarns into fine linen fabrics. Practically all of this work is done in limited areas in Ireland, Scotland, northern France, and Belgium, where a high degree of skill has been developed by many generations of workers.

Upholstering tow, which may be regarded as a byproduct, is used for stuffing material in upholstered furniture and in automobile and railway car seats.

The seed of fiber flax is also a byproduct. That which is not needed for sowing goes to the crushing mills, where it is used in the same manner as seed of seed flax in the production of linseed oil for paints and varnishes and in linseed cake for stock feed.

The shives beaten out by the brake and scutchers are used for fuel to furnish steam for operating the machinery in the scutching mill.

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U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1729

MACHINERY FOR DUSTING COTTON

DUSTING COTTON PLANTS with finely powdered calcium arsenate has been the most economical and successful means used for the control of the bollweevil for over 15 years. Successful results from dusting, however, depend largely upon the type and efficiency of the dusting machinery selected.

This bulletin is intended to help the grower select the machinery that is best suited to his needs and the conditions existing on his own farm. It supersedes Farmers' Bulletin 1319, Cotton Dusting Machinery.

Washington, D.C. Issued July 1934

MACHINERY FOR DUSTING COTTON

By R. C. Gaines, *Entomologist, Division of Cotton Insects, Bureau of Entomology*, and D. A. Isler, *Assistant Agricultural Engineer, Bureau of Agricultural Engineering*[1]

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NEW DEVELOPMENTS IN COTTON-DUSTING MACHINERY

MANY CHANGES and improvements have been made in the designs and construction of dusting machinery since 1923, when the last publication of the Department of Agriculture on this subject was issued. It is the purpose of this bulletin to furnish information that will help the cotton farmer to select the dusting machinery best suited to his individual requirements.

For over 12 years specialists in agricultural engineering and entomologists of the Department have been working in cooperation in the development of new and better types of dusting machinery and have furnished interested manufacturers with detailed descriptions and specifications that have resulted from this work. They have also assisted in testing and improving models submitted by manufacturers. As an outcome of this cooperative work satisfactory machines can now be purchased to meet practically every condition found on either small or large farms and at prices within the means of practically every cotton grower.

SELECTION OF DUSTING MACHINERY

To control the bollweevil it is generally necessary to dust the cotton at intervals of 4 or 5 days until the weevils have been reduced in numbers below the point at which they cause appreciable injury. To accomplish this, a type of machine should be selected with capacity for covering the area to be dusted well within this 4- or 5-day period. As an aid in determining the best type of machine to meet individual needs, the capacities of different types and models discussed later in this bulletin are there indicated. In calculating the machine capacity, allowance must be made for the probability that unfavorable weather or other conditions may interrupt or delay dusting. Therefore the daily and seasonal acreage that each machine can reasonably be expected to dust, as given herein, is about 25 percent less than the area that could be covered if it were possible to use the machine continuously.

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[1] M. D. Kearney conducted the field and calibration tests with the cotton-dusting machines discussed in this bulletin. G. A. Maloney assisted the writers in the preparation of the bulletin.

On large, open fields, clear of stumps or other obstructions, the larger types of machines will be found most efficient and economical, whereas fields of small size, irregular in shape, or with short rows requiring frequent turns, or containing stumps, will require the small machine of the one-mule type or the saddle gun or hand gun.

The selection of dusting machinery should be influenced to some extent by the character of labor available for its operation. However, little difficulty should be encountered with the improved machinery now on the market, since most of the newer models can be successfully operated by any intelligent farm hand, if he is carefully instructed.

Calcium arsenate in a dry, finely powdered form, such as is recommended by the Bureau of Entomology for control of the bollweevil, requires especially designed machinery. Many models of dusting machines that have been placed on the market are totally unsuited for the proper distribution of calcium arsenate, and much loss to farmers has resulted from their use. The types of dusting machines described herein, all of which can be purchased, have been designed to secure good distribution of the dust.

In selecting a machine the following points should be noted:

(1) The dusting machine should be provided with some device in the hopper that will keep the dust constantly agitated and in a light and fluffy condition, so that it will flow readily and at a uniform rate from the hopper. This is necessary to overcome the pronounced tendency of calcium arsenate to become sticky by absorbing moisture from the air and to pack quickly when subjected to vibration.

(2) The feeding mechanism should be such as will keep an even quantity of dust flowing through the feed opening at any desired poundage per acre.

(3) All parts of the machine, such as the agitator, the feeding mechanism, and the channels through which the air and dust pass, should be of easy access for cleaning, and the discharge tubes should be smooth on the inside and free from square turns, or sharp curves, since at such places the dust may accumulate and retard the flow or even stop it entirely.

(4) The dust-ladened air should have free and unobstructed passage through the machine and discharge tubes at all times.

(5) Dusting machines should be constructed of as light material as possible, to avoid excessive weight, but should be strongly braced to withstand the strain to which they will be subjected in field operations, particularly so as to avoid break-downs which might prevent adequate control of the weevil.

DAY OR NIGHT DUSTING

The discharge of calcium arsenate from the nozzles should be in the form of a light dust cloud or fog. If lumps or small pellets are discharged they represent so much waste, as only the very fine particles will adhere to the plant and be effective in poisoning the weevil. It follows that such dust, prior to settling upon the plants, is easily blown away. For this reason a great deal of the dusting of cotton is done at night in localities where the air is then generally more calm and when the dew present on the plants causes better adherence of the dust. Under these conditions and with a downward discharge, the dust will float among the plants and settle more evenly on all the parts.

With the better machines now available the blowing away of the dust is overcome to some extent by increased fan power and nozzle adjustment to direct the dust with greater force downward among the plants, and with such machines daylight dusting is possible during periods of light air movement.

The most satisfactory results from dusting, however, will be secured during those periods of either day or night when there is little or no air movement, and such periods should be taken advantage of by the farmer.

Dusting at night usually requires artificial lighting. Repairs to the machinery are more difficult then, and it is less easy for the driver to note whether the discharge of the dust is continuous and in a cloud sufficient to cover the plants properly. Furthermore, the presence of heavy dew requires the use of machinery so constructed as to keep the moisture from interfering with important moving parts. The disagreeable features and slight additional cost attending the night dusting are compensated for, however, by the superior results obtained.

TYPES OF DUSTING MACHINES

The many different models of machines offered for sale may be grouped in the following classes, or types, each type having certain well-defined mechanical features and purposes:

(1) The hand guns and saddle guns, the machinery of which is operated by a crank turned by hand.

(2) The traction machine in which the power for operating the dusting mechanism is taken from the traction wheels through chains or gears.

(3) The power duster which is operated by a gasoline engine mounted on the platform and connected with dusting mechanism by a belt or shaft.

(4) The tractor-power duster which is mounted on a platform and bolted and braced to the rear of a tractor, the power for its operation being furnished from the tractor power take-off.

A brief description is given of these various types of machines. Their acreage capacity and their adaptability in meeting different requirements are indicated.

HAND GUN

The hand gun is the smallest type of dusting machine. It is carried by the operator, supported by straps across the shoulders, is cranked by hand, and has a single nozzle for dusting one row of cotton (fig. 1). It is constructed of sheet metal sufficiently strong to withstand the rough handling that a machine of this type usually receives from the average laborer. It weighs about 20 pounds when the hopper is full of dust. In order to prevent strain or fatigue when cranking it is very important that the hand gun be so balanced that the greatest weight will be as close to the body of the operator as possible. The operation of a hand gun is a laborious task at best. This makes it the least satisfactory of the various types of dusting machines.

The chief advantages of hand guns over other and larger types are their lower initial cost and their adaptability for use in places inaccessible to larger machines and for dusting areas too small to justify the purchase of a larger and more expensive machine. As a general rule one hand gun will take care of the dusting of about 8 acres of cotton.

Hand guns which will last 3 or 4 years, if given reasonable care, can be purchased for not over $18 or $20, but it is poor economy to use hand guns unless no other type of machine is found suitable for the local conditions.

SADDLE GUN

The saddle gun is constructed of lightweight sheet metal and is designed to be attached to the pommel of a saddle. It is operated by the rider by hand-cranking (fig. 2). These machines have two nozzles, one extending down on each side of the animal, and dust two rows at a time. The nozzles of some models can be raised or lowered for the dusting of plants of different heights.

The saddle gun can be used under practically all conditions encountered in cotton dusting and in places where no dusting machine mounted on wheels could be operated successfully. It was not designed to replace the larger types of machines, but rather to supplement them and meet a demand for a machine priced between the hand gun and the larger and more costly models, and to permit the operator to ride and thus avoid contact with the dust cloud and wet cotton during night operation.

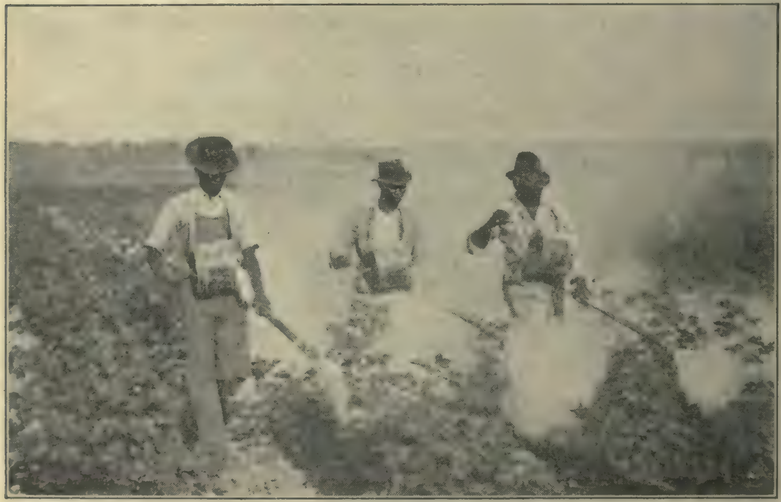

FIGURE 1.—Dusting cotton with hand guns.

Saddle guns now on the market sell for from about $47 to $57, complete with saddle and attachments, and one should dust 15 acres in a day or night and care for the dusting of 40 to 50 acres of cotton in a season.

ONE-MULE MACHINE

The name "one-mule machine" has in the past been used to designate a machine drawn by one animal and having 2 nozzles, which would dust 2 rows of cotton (fig. 3). At present, however, there are available one-mule machines equipped with 4 nozzles,

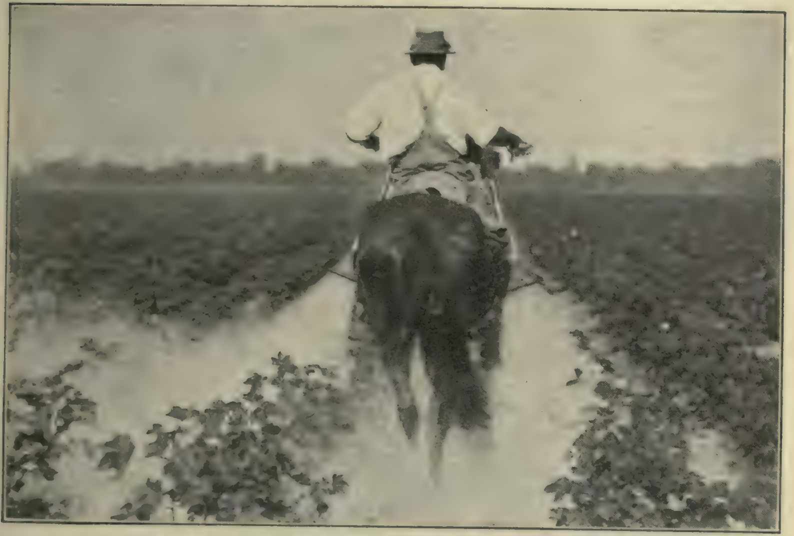

FIGURE 2.—Saddle gun in operation in a cotton field.

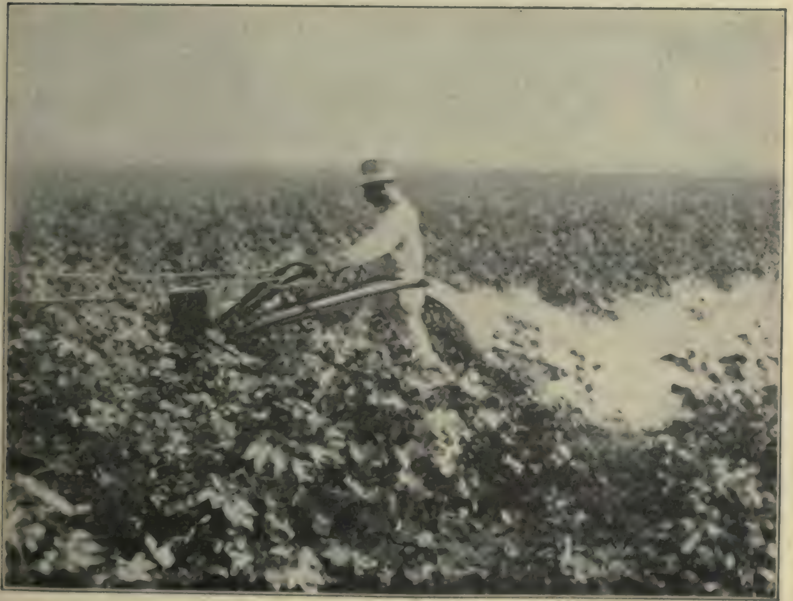

FIGURE 3.—One-mule dusting machine delivering dust.

which will dust 4 rows or more at each trip. Some are narrow models for use between 2 rows of cotton, with the operator walking. Of these, there are one-wheel machines with shafts, others with 1 or 2 wheels and a singletree hitch, and others with 2 wheels and a caster wheel in front by which the machine is guided by the operator. The riding type has 2 wheels and straddles 1 row of cotton.

The most satisfactory one-mule machines are of strong but light construction for ease in handling by the driver, and are equipped with ball bearings on all important moving parts to insure constant and efficient operation with the power provided by the traction wheel. The walking type of the one-mule machine can readily be guided around stumps and turned at ends of rows, can be operated in any place in a cotton field where a mule or horse can walk, and is well adapted for use on hillsides and terraced land.

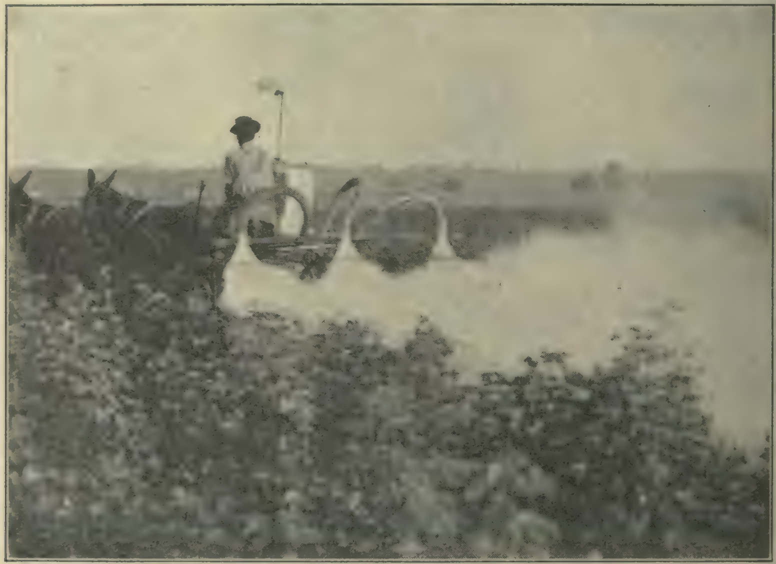

FIGURE 4.—Dusting cotton with a traction-power cart machine.

These machines range in price from about $65 for the walking type to $145 for the riding type. The hopper capacity of the various models ranges from 20 to 40 pounds of dust. The 2-nozzle machines will dust from 15 to 20 acres a day and care for the dusting of from 40 to 60 acres of cotton during a season, while the 4-nozzle machines will dust approximately twice as many acres as the 2-nozzle machines.

TRACTION-POWER CART MACHINE

The traction-power cart machine (fig. 4) is mounted on 2 wheels, the power for operating the dusting mechanism being taken from 1 or both wheels. In most models the axle is adjustable from 36 to 54 inches and is arched to a height sufficient to clear the plants in the row being straddled. These machines have from 3 to 5 nozzles, 1 nozzle over the row being straddled and the other nozzles over the rows on each side of the machine. Machines of this type are best suited for operation on large, open fields, clear of stumps or other obstructions, and the most modern and satisfactory models are fitted with ballbearings on all moving parts to lighten the draft and insure ease of operation. The hopper capacity ranges from about 35 to 75 pounds of dust, and the hopper can easily be refilled by the driver from a barrel of dust, which can be carried on the platform of the machine.

The price range on various models of this type now on the market is approximately from $175 to $300. One of these machines will dust from 35 to 50 acres in 10 hours and should care for the dusting of from 75 to 150 acres during a season.

POWER-OPERATED MACHINES

In 1922 the first model of a two-wheel-cart type of engine-powered cotton duster which could be safely and economically operated in a cotton field was designed by engineers of the Department of Agriculture at Tallulah, La. The aim was to develop a machine that would produce a sufficient velocity of air to break up and separate the dust particles thoroughly, effect a uniform coverage of the cotton plants, and increase the acreage that could be covered in a day or night of operation. Several types of power dusters which meet the various conditions and requirements of cotton growers have been produced and placed on the market during the last 7 or 8 years. The most satisfactory power dusters are those that have the least complicated machinery and a gasoline engine of sufficient power mounted on a platform of a light but sturdily built two-wheel cart.

SINGLE-NOZZLE TYPE

The single-nozzle, power-operated duster (fig. 5), several models of which have been placed on the market during the last 7 years, follows closely the general design of the duster developed by engineers at the Tallulah laboratory. It is provided with a single nozzle at the rear which is moved constantly from right to left and through which dust is discharged down among the cotton plants by a powerful blast of air from the fan, dusting 7 or 8 rows of cotton at each trip across a cotton field.

Machines of this type sell for about $300. They require two mules or horses to draw them and will care for the dusting of from 200 to 300 acres in a season.

MULTIPLE-NOZZLE TYPE

In the class of power-operated dusters are models having 4 or 5 nozzles each, which require only 1 mule or horse to draw them, and will dust 4 or 5 rows of cotton at each trip over a field. Other models of this type, but of heavier construction, requiring 2 mules or horses to draw them (fig. 6), are equipped with additional nozzles and will dust up to 10 rows of cotton at each trip. These larger models carry larger quantities of dust in the hoppers and are intended to meet the needs of the larger cotton growers. Some large power dusters have frames for supporting the dust-discharge tubes that extend beyond

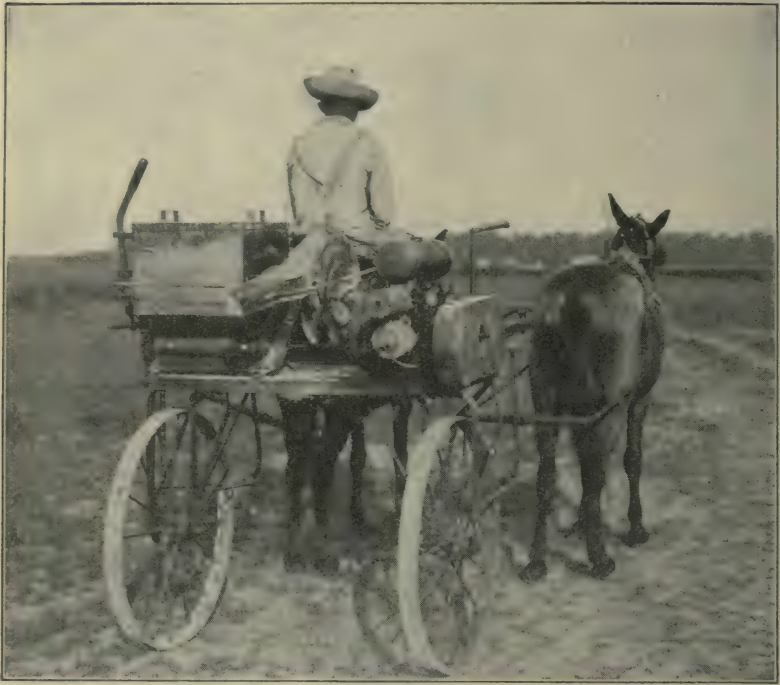

FIGURE 5.—Single-nozzle type of engine-powered cotton duster. In this duster the feed mechanism is operated by a chain and sprocket drive from one of the wheels.

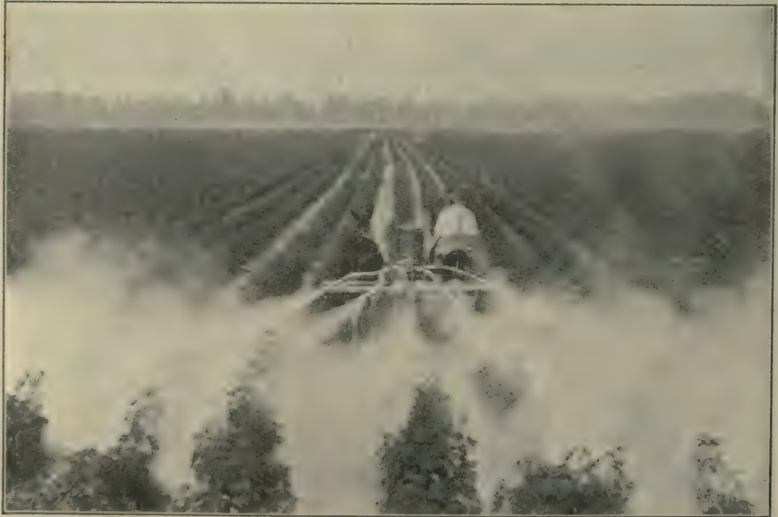

FIGURE 6.—Five-nozzle engine-powered duster in operation.

the sides of the machine. These frames can be raised or folded by the driver from his position on the seat to permit the machine to pass through narrow gates or other openings without damage and to avoid obstructions that may be encountered in turning at ends of rows while dusting or in moving the machine to or from the field.

UNMOUNTED DUSTING UNITS

Power-dusting units mounted upon a wooden base are also on the market at a price considerably lower than that asked for the duster mounted on a cart. These units consist of a complete dusting machine and a gasoline engine, assembled and ready for operation, which can be mounted on any homemade cart or other 2-wheel vehicle that the farmer may have or may be able to construct from parts of other farm machinery not in use.

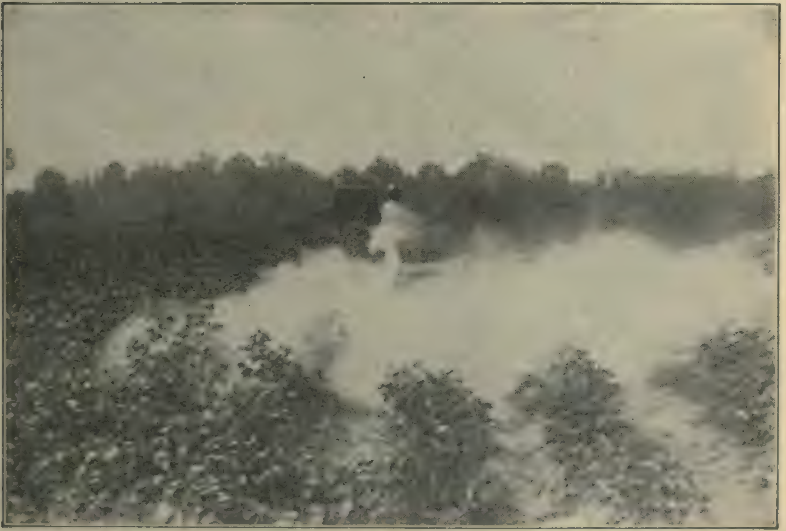

FIGURE 7.—Single-nozzle type of tractor-operated duster.

TRACTOR-OPERATED DUSTERS

Dusting machines mounted on a platform that can be bolted and braced to the rear of a tractor (fig. 7) and operated from the tractor power take-off have been in use for several years on farms where tractors have been employed for cotton cultivation. One type has a single large nozzle that moves back and forth and directs the dust cloud down among the cotton plants. Another type has a single rigid, but adjustable, discharge outlet. From 7 to 8 rows of cotton can be dusted with these machines at each trip across a cotton field. Other types of dusting machines for operation by tractors are equipped with five or more discharge tubes.

The speed at which a tractor can be driven through a cotton field makes it possible to dust a greater acreage than with horse-drawn machinery of equal row capacity.

COMBINATION CULTIVATOR-DUSTERS

In some localities where riding cultivators are used there has developed a demand during the last few years for cotton-dusting equipment that can be attached to horse-drawn cultivators in order that dusting and cultivation may be accomplished at one operation. Some of the light dusting machines, of the hand-gun or saddle-gun type, can be attached to the frame of a cultivator and operated by chain and sprocket from the cultivator wheel. The 1-row cultivator-duster (fig. 8) is provided with 1 nozzle for dusting 1 row of cotton, and the 2-row duster (fig. 9) with 2 nozzles for dusting 2 rows, the dust being discharged behind the driver's seat.

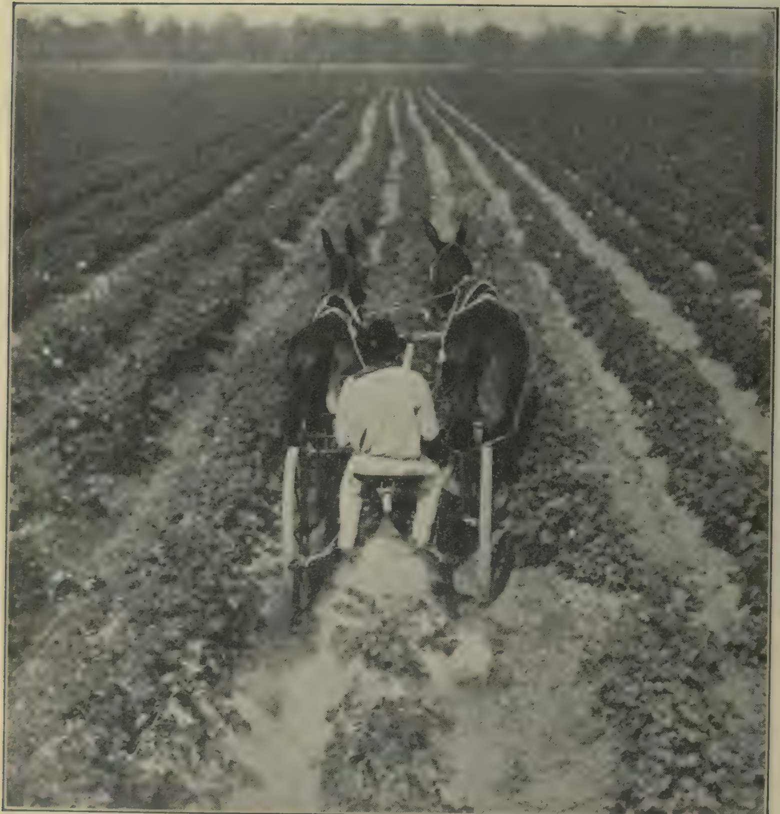
FIGURE 8.—Hand gun attached to a one-row cultivator and geared to the wheel.

The dusting capacity of the cultivator-dusters is limited to the acreage that they will cover during cultivation, and these machines are not suitable for dusting after cotton is laid by. They may be used in localities where cotton produces a moderate growth of plants and where the air during the day is sufficiently calm to make effective dusting possible. In localities where weevil damage may continue, or occur after cultivation is completed, machines of other types will be required for the necessary dusting.

LIGHTING EQUIPMENT

When operating dusting machinery at night it is necessary that a lighting system be provided that will withstand the jars and vibrations to which it will be subjected by the travel of the machine over a rough cotton field. For use on the larger machines an automobile headlight or spotlight, mounted on a standard for proper focusing, and operated by a storage battery carried on the platform of the cart, is satisfactory and economical. A satisfactory but considerably more expensive carbide light of a special design for dusting machines was developed about 10 years ago and has been furnished by some manufacturers of dusting machines as standard equipment. Lights of this type sell for from $30 to $45.

Such brilliant illumination is not necessary for night operation of the one-mule machine or saddle gun. For the one-mule machine an ordinary oil-burning lantern or a dry-cell electric lamp mounted or hung on the frame will furnish sufficient light to meet ordinary requirements. A satisfactory light for use with the saddle gun is furnished by either a small carbide or dry-cell-electric head lamp fastened to the front of the rider's cap or worn on a band around his head. Such a light can be purchased at most hardware or general-merchandise stores for about $1.50 for the carbide lamp and about $3.50 to $4 for the electric lamp. These small head lamps will also be found satisfactory when dusting on very dark nights with hand guns.

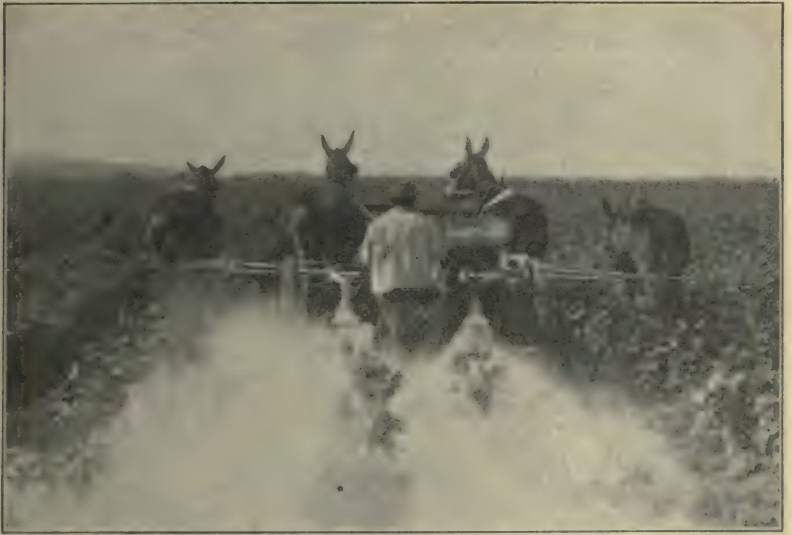

FIGURE 9.—Saddle gun attached to and operated by a two-row cultivator.

COST OF OPERATION

The cost of dusting depends so much upon the farmer's personal supervision and management of his dusting operations, the interest taken by the labor employed in the operation, and the care given the dusting machinery (all of which are vital to economic operation) that it is practically impossible to give any figures that could apply in all cases. However, in the operation of the larger types of dusters on many farms, records of which have been carefully kept over a period of years, the cost of a season's operations very closely approximates an average of 75 cents to $1 for each acre application, depending upon the cost of the dust. This figure includes a depreciation charge on machinery, the cost of labor, the cost of dust, and upkeep and repairs on machines.

CARE OF DUSTING MACHINERY

The most efficient and profitable service from any dusting machinery can be secured only through the use of intelligence in its care and operation. Most of the dusting machines now on the market are shipped from the factory assembled and ready for field operation, excepting that the wheels and pole or shafts are usually detached for shipment, to reduce the bulk. All gears and moving parts are usually oiled and greased.

Before the machine is taken to the field, study the instructions for operation furnished by the manufacturer and examine the machine carefully to be sure that every part will work smoothly and without friction. This careful inspection should always be repeated before each day's operations, and oil or grease should be applied as often as may be found necessary. Proper lubrication of all moving parts of a dusting machine is as necessary for efficient operation and long service as for an automobile, a tractor, or any other piece of farm machinery.

Where possible, keep dusting machinery under cover and out of the weather when not in use. At the end of the season clean the machine thoroughly, remove all dust from the hopper, and blow all dust from the channels through which the dust passes, including the rubber or metal hose lines. If the machine has rubber hose see that it is not kinked or sharply bent, as these defects tend to become permanent if permitted to remain for any great length of time.

AIRPLANE DUSTING

The airplane as a cotton-dusting machine cannot be considered in the same class with farmer-owned dusting machinery operated on the ground. However, in many districts of the Cotton Belt during the last 7 years, the airplane (fig. 10) has come to be regarded as a valuable and important machine where the control of the bollweevil and other cotton insects on an extensive scale has been necessary.

The purchase of an airplane equipped for dusting and the employment of an experienced pilot and mechanic for its operation and upkeep would be justifiable from an economic standpoint only for the very largest cotton producers, or corporations engaged in unusually large farming operations.

From 1922 to 1930, engineers of the Department of Agriculture carried on extensive experiments at Tallulah, La., in developing dusting mechanisms that could be installed and used in different makes and models of airplanes for the control of the bollweevil and other insects. These experiments showed airplane dusting to be so successful and aroused such interest among cotton growers and airplane manufacturers that corporations were organized for commercial airplane dusting, and since 1925 this industry has become well established. These organizations operate under contracts made with cotton growers on a basis of a given price per acre to be dusted or at a given price per pound of dust to be applied.

Commercial dusting of cotton with airplanes is done most economically for the farmer on a community or "syndicated-farms" basis. This involves the pooling of cotton acreages by a number of farmers whose farms are reasonably close to one another, under contract with an airplane-dusting company at a price based on the combined cotton acreage of all who sign contracts. Under this plan the cost per acre for each farmer signing the contract depends upon the total acreage of all who are associated with him in the pool, the cost to the farmer having a small acreage being the same per acre as to the one having the largest acreage. The price per acre includes the cost of dust and all other charges, and the dusting is done under the direction and supervision of the farmer himself. In another form of contract the dusting company sells only its service in applying dust at a definite price for each acre application, or at a given price per pound of dust applied, the farmer furnishing or paying for the dust. By this plan the farmers may accomplish a saving if they are able to purchase the dust cooperatively at a lower price than the dusting company can furnish it.

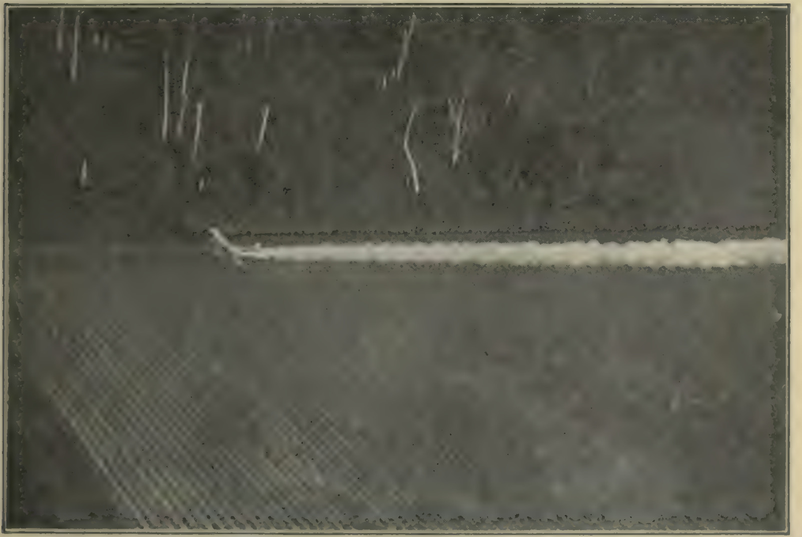

FIGURE 10.—Airplane dusting cotton.

The airplane dusting of cotton presents some outstanding advantages to the farmer over dusting with ground machinery. Of most importance is the fact that it is possible immediately after heavy or protracted rains to fly over muddy or boggy fields where weevils may be doing serious damage and where no other type of duster could be operated, possibly for several days.

The speed at which an airplane is flown and the much greater number of cotton rows it dusts at each flight over a field make possible the dusting of approximately 350 or more acres of cotton per hour, which is many times the acreage that can possibly be dusted with any other type of machine in the same length of time.

Airplane dusting is done entirely during daylight and generally during the early morning and late afternoon, as those periods are usually the safest for flying at the low altitudes necessary to insure the dust being driven down among the cotton plants. The velocity at which the dust is driven from the airplane by the air blast from the propeller is so much greater than that from the fan in the ground machines that moderate ground air currents are overcome, and the dust is permitted to settle and cover the plants. The use of airplanes enables the grower to avoid the disagreeable conditions encountered in night dusting, which is often necessary when most types of ground machines are used.

Where it is possible for the farmer to engage airplane-dusting service he will be saved the necessity for investing in dusting machinery and in animal or other power, and labor for its operation and upkeep. Experience has proved that the cost to the farmer of airplane dusting has been no greater than for dusting with other kinds of machinery.

METHODS TO BE AVOIDED

The following dusting methods have proved to be unsatisfactory:

(1) Broadcasting calcium arsenate dust by the use of a powerful motor-driven fan through a single nozzle with the idea of covering large areas from fixed points on the edge of or in the field. The objection here is the lack of uniformity of coverage.

(2) The old-time bag-and-pole method (used with paris green for the control of the cotton leaf worm) is not suitable for applying calcium arsenate dust to cotton plants. The calcium arsenate used for dusting is very finely divided, and the particles pack and stick together in such a way that the dust cloud necessary to give effective control of the bollweevil cannot be produced by this method.

Farmers' Bulletin 1329, The Boll Weevil Problem, and Leaflet 37, Poisoning the Cotton Boll Weevil, are on sale by the Superintendent of Documents, Government Printing Office, Washington, D.C. For additional information regarding the control of insects in the cotton field write to the State agricultural experiment station, or the Bureau of Entomology, United States Department of Agriculture, Washington, D.C.

U.S. GOVERNMENT PRINTING OFFICE: 1934

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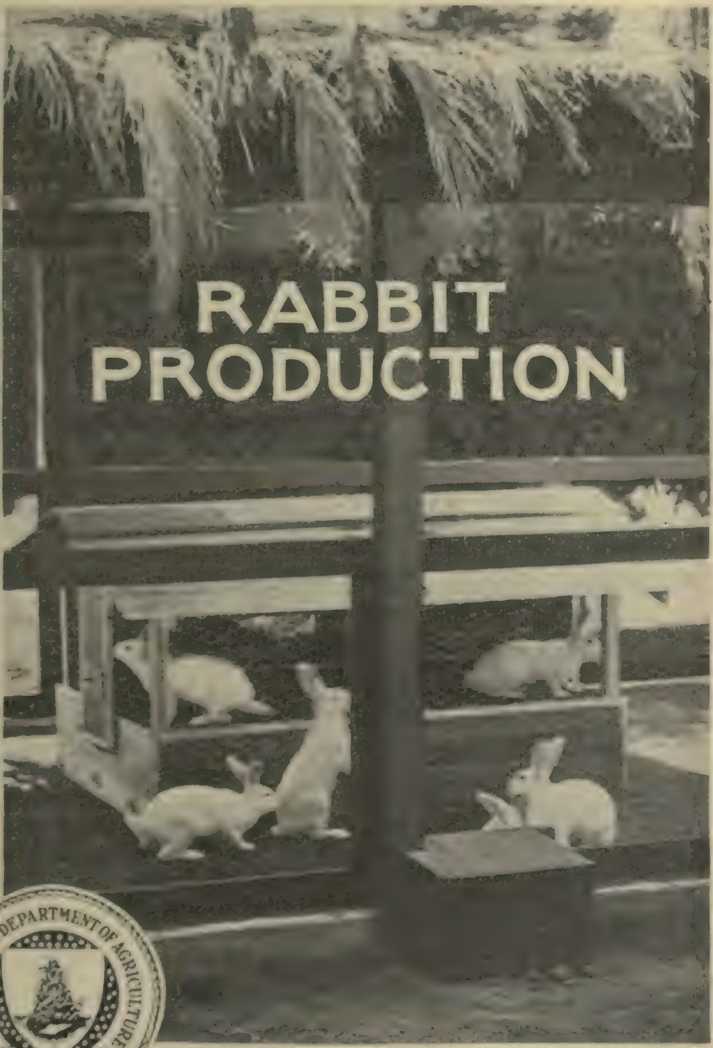
U. S. DEPARTMENT OF
AGRICULTURE

FARMERS' BULLETIN No. 1730



RABBIT PRODUCTION

RABBIT RAISING has become an important minor farm industry in some parts of the United States, and it fits in well as a side line to general farming. No animal is better adapted for use in 4-H club work than the rabbit, and on a small scale rabbit raising affords the suburban family an excellent opportunity to reduce its meat bill and at the same time provide an agreeable occupation for boys and girls.

Rabbits are raised for both food and fur. The market for rabbit meat is established in some sections, but in others the prospective rabbit raiser will need to develop this outlet for his product before making heavy investments. Rabbit fur, on the other hand, is already used extensively—in fact, more than any other kind.

This bulletin sets forth the essential principles of rabbit raising and tells how to apply them in practice. It supersedes Farmers' Bulletin No. 1519, Rabbit Skins for Fur; and the following leaflets: No. 4, Raising Domestic Rabbits; No. 15, Rabbit-House Construction; and No. 22, Chinchilla Rabbits for Food and Fur.

Washington, D.C. **August 1934**

RABBIT PRODUCTION

By Frank G. Ashbrook, *principal biologist*, and Chas. E. Kellogg, *biologist*, *Division of Fur Resources, Bureau of Biological Survey*

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INTRODUCTION

RABBIT raising no longer has to do merely with pet stock, and in some parts of the country it has developed into a business of large proportions. A number of commercial rabbitries have been established, both on large and small farms and in the suburbs of cities (fig. 1). The future of the industry depends mainly upon its ability to produce rabbit meat and fur in commercial quantities.

RABBIT MEAT AS FOOD

At present there are relatively few established markets where rabbit meat is displayed and regularly offered for sale. Consequently the meat is usually produced for home and local consumption, and the general public is not well acquainted with it. Once constant supplies are available, however, and the public recognizes its good qualities, the demand should substantially increase.

Rabbit meat is a good source of efficient protein and iron. Analyses made by the Bureau of Animal Industry of the Department of Agriculture show that it has about the same protein content as other lean meats. Of the four samples of rabbit meat analyzed, the average for protein was 20.4 percent, and for fat, 11.9 percent. The fuel value averaged 855 calories per pound. The rabbits studied were of the Chinchilla, American White, and New Zealand breeds and ranged in age from 10 weeks to 18 months.

In terms of live weight, rabbits afford about the same proportion of edible meat as do young broiling chickens, but the carcass of the rabbit contains a larger proportion of meat. Including the heart, liver, and kidneys, the dressed carcass averages 56 percent of the live weight, and 82 percent of this is edible.

The edible organs, which constitute 5 percent of the live weight, should not be considered waste. Rabbit livers, especially, are palatable, and, like the livers of other meat animals and poultry, are valuable in the diet in helping to make red blood cells.

For use in his own home and in connection with efforts to popularize his product, the rabbit breeder will find it helpful to obtain a few copies of Leaflet 66, Rabbit Recipes, available at 5 cents a copy from the Superintendent of Documents, Government Printing Office, Washington, D.C.

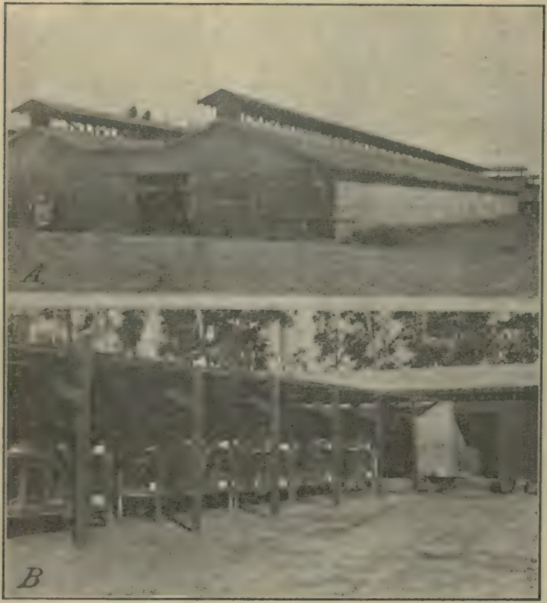

FIGURE 1.—Typical rabbitries: *A*, Breeding houses of large commercial rabbitry; *B*, small rabbitry, typical of many that are operated in various sections of the United States.

RABBIT SKINS FOR FUR

Regardless of size and color, all rabbit skins have commercial value. They are used more extensively by the fur trade than any other kind of fur, more than half the rabbit skins utilized being dressed and dyed and made into fur garments and trimmings for women's coats, suits, and dresses. The remainder, or skins not suitable for garments, are used as linings for men's and boys' gloves and in the manufacture of felt hats. Even the fine shreds into which the skins are cut in separating the fur for felting purposes are utilized in the manufacture of glue.

Many wild fur-bearing animals are disappearing from different parts of their former ranges, and rabbit skins are being substituted for those of wild animals in the manufacture of garments. Fur dressers and dyers have mastered so well the art of imitating other furs by modern methods of plucking, shearing, and dyeing that the pelt of the rabbit, which lends itself readily to imitation processes, is being offered for sale under a variety of trade names (p. 36). In many instances it is replacing such costly skins as ermine, seal, beaver, and leopard.

PROSPECTIVE PROFITS

Market prospects for rabbit meat and fur promise an encouraging future for the producer, but the business is not in the "get-rich-quick" class. Unwarrantedly large returns have frequently been predicted or promised to prospective investors, in spite of the heavy risks usually known to accompany such lures. The promoter who tries to impress the prospective investor with statements of fabulous returns from raising rabbits, or with misleading endorsements, unwittingly admits that his offering cannot stand on its own feet.

Irresponsible sellers of rabbits often "guarantee" that certain profits will be made or dividends paid, or even that they will buy back or resell when the purchaser wants his money. Such guarantees can be depended upon only when their makers have sound financial backing. Promises of this nature, which are made to establish confidence and lull suspicion, should put the prospective purchaser on his guard. They indicate a special need to investigate not only the securities offered but also the responsibility of the guarantor.

It is unwise for the beginner to make hasty investments in rabbits. Although good profits are obtained from the sale of breeding animals, the exceptional prices are usually received only by experienced breeders. Even though the sale of breeding animals may in some cases net the owner more than marketing the rabbits as food, a beginner should never lose sight of the fact that rabbits are raised primarily for food and fur. Before he enters the industry, one who hopes to obtain an adequate return on his investment over a period of years should carefully consider the economic side of the problem. Success is largely dependent upon quality of animals, economy of production, and efficient marketing.

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FIGURE 2.—Administration building, United States Rabbit Experiment Station, Fontana, Calif.

UNITED STATES RABBIT EXPERIMENT STATION

The recommendations made in this bulletin are based largely on findings at the United States Rabbit Experiment Station, established and maintained at Fontana, Calif., by the Bureau of Biological Survey, in cooperation with the Fontana Farms Co. and local rabbit breeders. At this station improved methods are developed for producing rabbits with meat and fur of fine quality, for insuring sanitary surroundings, and for preventing outbreaks of parasitic and other diseases. Although the work is conducted in the one locality, the fundamental principles developed are applicable in any section of the country.

The equipment of the station, on the site of a 5-acre orange grove, includes an administration building containing offices and laboratories (fig. 2); various open and closed types of houses sheltering hundreds of hutches and cooled on hot days by a sprinkler system; the director's residence; and a large storage house where hay and grain are kept and prepared for feeding. A carpenter shop, a garage, a small slaughterhouse, and a concrete manure pit complete the lay-out. When established in 1927 the station accommodated 140 animals, but additional equipment has made it possible to provide for 620.

Various groups of breeders hold monthly meetings in the administration building to discuss problems pertaining to rabbit raising. Other groups desiring to use the station's facilities for this purpose may communicate with the director, United States Rabbit Experiment Station, Fontana, Calif. Fontana is accessible from Los Angeles on the Pacific Electric and the Santa Fe Railroads or by automobile.

THE RABBITRY AND ITS EQUIPMENT

The kind of buildings needed for a rabbitry depends upon the location, the climate, and the money to be invested. Whatever the extent of the business, the producer should plan for construction and equipment that will facilitate handling the animals with a minimum of manual labor. Care in feeding, breeding, and handling the rabbits, as well as in cleaning the hutches and keeping the house sanitary, is of the utmost importance. Construction, therefore, should be as simple as possible, and ample provision should be made for light and for fresh air.

In mild climates little or no protection is required other than a good roof, and the sides of the hutches may be constructed either wholly or in part of wire netting. Where there is much cold weather, additional protection must be provided. This may be achieved by enclosing the sides and back of each hutch with wood or by placing the hutches in a shed or other shelter. Rabbits must also be protected against extremes of heat. This may be done by placing the hutches in the shade of trees or shrubbery, or under the shade of lattices. Protection against rain, too, must be provided, for rabbits cannot stand exposure that results in the coat becoming thoroughly wet.

HUTCHES

To provide individual quarters for each mature animal, rabbit hutches should have about 10 or 12 square feet of floor space. The usual hutch is 4 feet long, 2½ feet deep, and 2 feet high, inside measurements, although hutches for Flemish Giants are frequently 5 or 6 feet long. Where there is plenty of room the hutches should be in single tiers. Using more than two tiers makes it inconvenient to reach and clean some of the hutches, and the animals in them are more difficult to observe. Great strength is not required in hutches, as rabbits seldom make determined efforts to escape. The animals are more easily cared for and less likely to become diseased in well-built hutches, however, than in poorly constructed temporary ones, which become foul unless frequently cleaned and rebedded with straw, leaves, or other absorbent. Self-cleaning hutches (fig. 3) need no bedding and are easily kept in good condition.

Hutches should be so located in the rabbitry as to prevent unusual excitement. Domestic rabbits are quiet in nature and enjoy being undisturbed, especially during the middle of the day.

Many different types of hutches have been used, but the most satisfactory are (1) the semi-enclosed hutch constructed with ends and back of wood, for use in colder climates; (2) the open-air wooden hutch, consisting of a wood frame with front, back, and ends of wire, usually 1-inch-mesh woven poultry wire; and (3) the all-metal hutch. If tightly built shelters are used, the open-air and the all-metal hutches are satisfactory in colder climates, but they are particularly suitable for use in mild climates.

With either of these hutches any of three general types of flooring may be used: (1) Wooden slats varying in width from 1 inch to 1½ inches and in thickness from one-half to three-fourths of an inch, spaced approximately one-half inch apart; (2) either perforated metal, or galvanized hardware cloth, ½-, ⅝-, or ¾-inch mesh, no. 15 to no. 18 gage, having a bottom support; or (3) solid boards having a slope toward either the front or the back. The perforated metal floor provides the rabbit maximum comfort and permits effective treatment with fumigants and disinfectants.

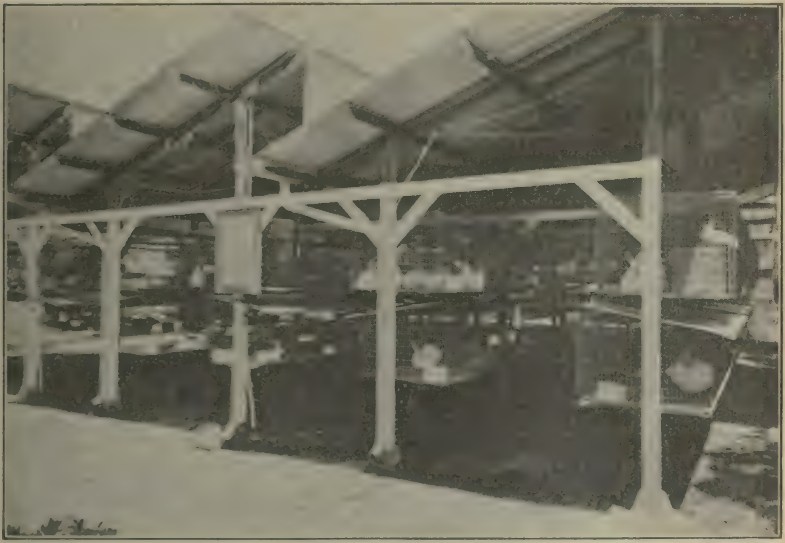

FIGURE 3.—Self-cleaning hutches at the United States Rabbit Experiment Station. Feeding and watering, as well as cleaning, are facilitated by using hutches of this type. See also figure 4.

ALL-METAL HUTCH

Domestic rabbits, confined in rather small quarters, often become restless and gnaw exposed surfaces of wood or other readily destructible material within the hutch. In such cases repairs are needed more or less continuously, the hutch looks unattractive, and sometimes unsanitary conditions develop. As a solution for this problem, the all-metal hutch (fig. 4) has been designed.

Use of metal exclusively in hutch construction seemed impractical until recently because of the large investment required. Now, however, electro-spot-welded wire fabric provides a suitable and relatively inexpensive material. Several types of rabbit hutch constructed of this fabric are manufactured and sold, and the Rabbit Experiment Station has designed all-steel hutches that can be economically constructed of stock materials by anyone with mechanical ability.

Convenient, two-compartment hutches as illustrated in figures 5 and 6 can be made for the most part of electro-spot-welded wire fabric.

In 24-inch widths this material can be used for the sides and ends. Labor can be saved by using one length of the wire fabric for all sides, bending it at the corners, but if separate pieces are cut for front, back, and sides these can be fastened together at the corners with spiral wire or a soft galvanized stovepipe wire of about 12 gage. In the same way the sides and ends after assembling can be attached to a bottom of either galvanized ⅝-inch-mesh hardware cloth or perforated metal sheets (p. 5). If a sloping roof is used on the hutch, as is required for

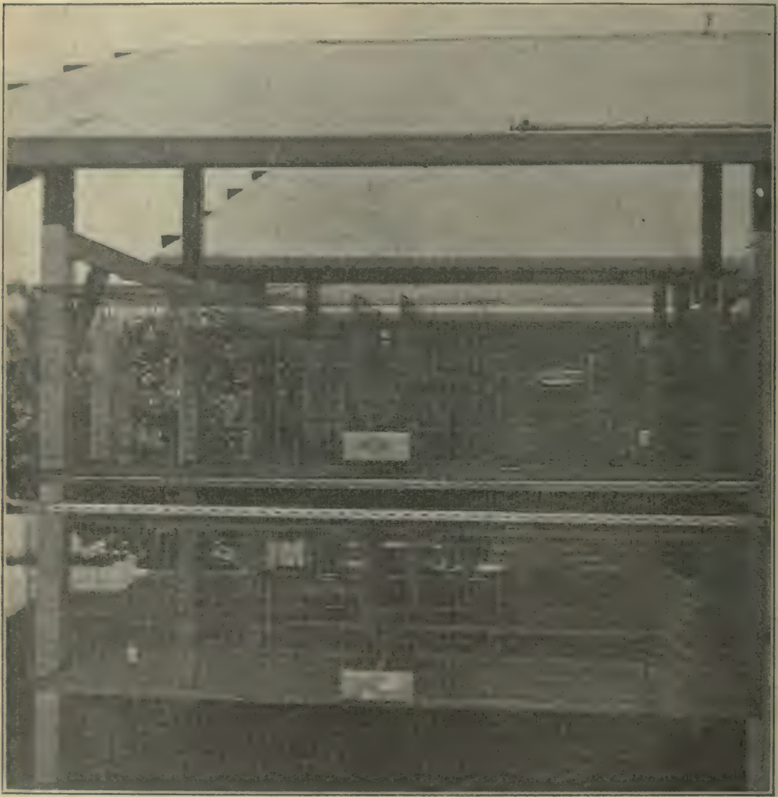
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FIGURE 4.—All-metal hutches. See also figure 3.

lower sections in tier installation, the end sections are bent to the desired pitch and this also provides additional rigidity. The top can be made of either electro-spot-welded wire fabric or galvanized sheet iron. The hay manger between the two compartments can also be constructed of the same materials, as shown in figure 5. The fabric can be cut as desired to provide openings for doors and feed trough, and permit access to the hay manger. Methods of constructing a wire lock or fastener, hinges, and partitions beneath the hay manger are illustrated in figure 6. Metal frames constructed of

1¼-inch angle iron can be used in installing hutches to give additional support to the bottom. Figures 3 and 11 illustrate the two-tier arrangement of these hutches.

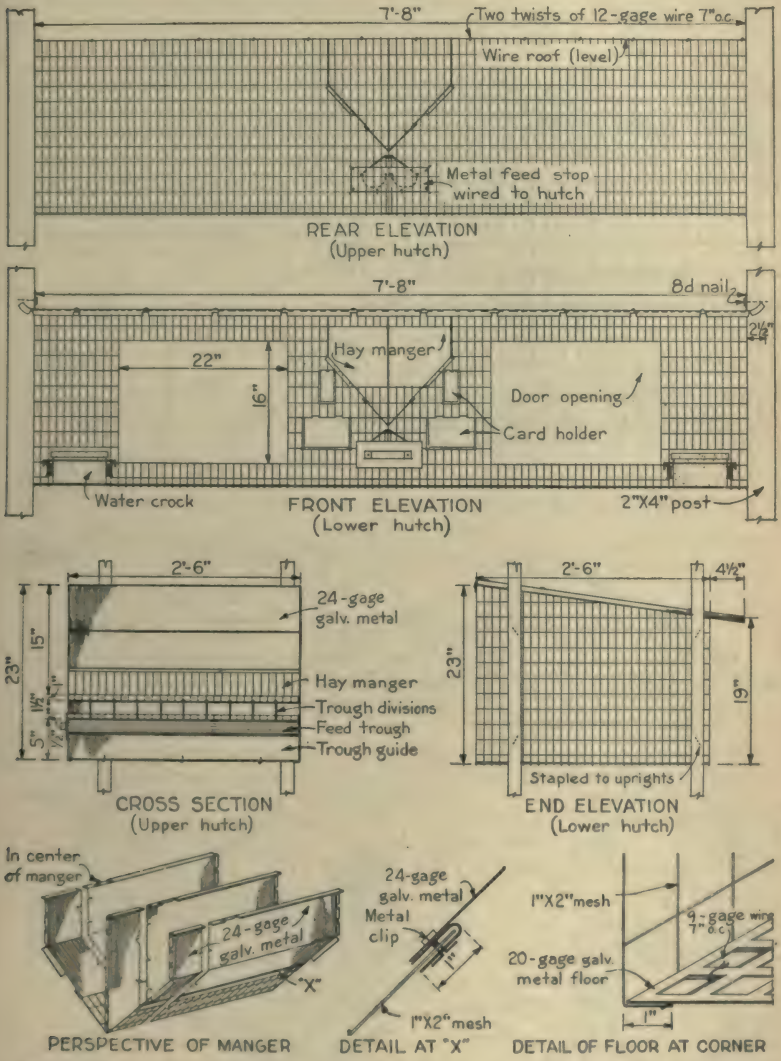

FIGURE 5.—Construction details for all-metal rabbit hutch. (Prepared by Bureau of Agricultural Engineering.)

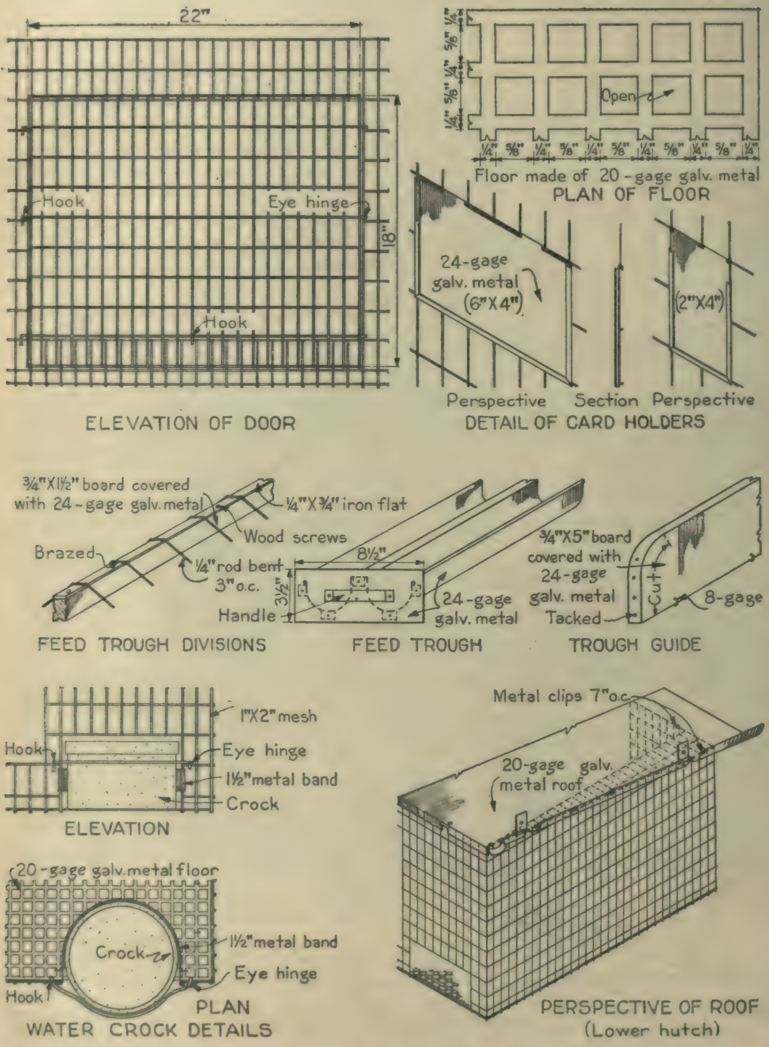

FIGURE 6.—Additional construction details for all-metal rabbit hutch. (Prepared by Bureau of Agricultural Engineering.)

Bill of materials.—As shown in figures 5 and 6, 2 all-metal hutches (1 upper and 1 lower) can be constructed of the following materials:

Wire fabric.—All wire fabric should be electro-spot-welded, 12½-gage, 2-inch vertical mesh, and 1-inch horizontal mesh. The following quantities are required:

51 linear feet, 24 inches wide, for roof and walls.
8 linear feet, 24 inches wide, for doors.

Galvanized sheet steel.—Wherever practical the edges of the galvanized sheet steel used should be turned under ¼ inch for stiffness. The following quantities are required:

1 sheet 24-gage, 4 feet by 8 feet, cut into the following pieces:
  4 pieces, 13 inches by 2 feet 8 inches, for sides of hay manger.
  2 pieces, 16 inches by 2 feet 8 inches, for center of hay manger.
  4 pieces, 1½ inches by 18 inches, for crock straps.
  4 pieces, 2 inches by 2 feet 6 inches, for manger mesh guard.
  4 pieces, 7 inches by 5 inches, for breeding-record cards.
  4 pieces, 3 inches by 5 inches, for feed-record cards.
  2 pieces, 1½ inches by 2 feet 6 inches, for feed-trough division.
  2 pieces, 12 inches by 3 feet 6 inches, for trough guides.
1 sheet 16-gage, 3 feet by 3 feet, cut into the following pieces:
  2 pieces, 4 inches by 9 inches, for front of feed trough.
  2 pieces, 1½ inches by 10½ inches, for feed-trough handles.
  2 pieces, 1 foot 3 inches by 2 feet 7 inches, for feed trough.
1 sheet 20-gage, 3 feet by 8 feet, for roof (not cut into pieces).

Galvanized sheet steel should be used for the floors of the hutches and should be perforated with ⅝-inch square holes ⅞ inch on centers both ways. The following quantity is required:

2 sheets, 20-gage, 2 feet 6 inches wide by 7 feet 8 inches.

Wire will be needed as follows:

5 linear feet, 12-gage galvanized soft wire, for lacing.
7 linear feet, 9-gage copper wire, for lacing.
2 linear feet, 8-gage copper wire, for lacing.

Miscellaneous.—The following additional materials will be needed:

2 pieces of strap iron, ¼ inch by ¾ inch by 2 feet 6 inches, for feed-trough division.
18 pieces ¼-inch-diameter iron rods, 10 inches long, for feed-trough division.
6 round-head wood screws, 3/16 inch by 1 inch, for feed-trough division.
16 large carpet tacks for trough guide.
53 brass clips or cotter pins, ⅛ inch by 9/16 inch, with flat heads (see detail "X" fig. 5).
4 common 8-penny wire nails.
Sixteen ¾-inch staples, 9 gage.
2 pieces wood boards (yellow pine or other species), ¾ inch by 1½ inches by 2 feet 6 inches, for feed-trough division.
2 pieces wood boards (yellow pine or other species), ¾ inch by 5 inches by 2 feet 6 inches, for trough guide.
4 earthenware crocks 7 inches in diameter, 4 inches deep.

OPEN-AIR WOODEN HUTCH

Though not so durable as the all-metal hutch, the wooden hutch with woven-wire sides and ends permits good circulation of air and is more sanitary than a solid hutch. It can be constructed as shown in figure 7, of the following materials:

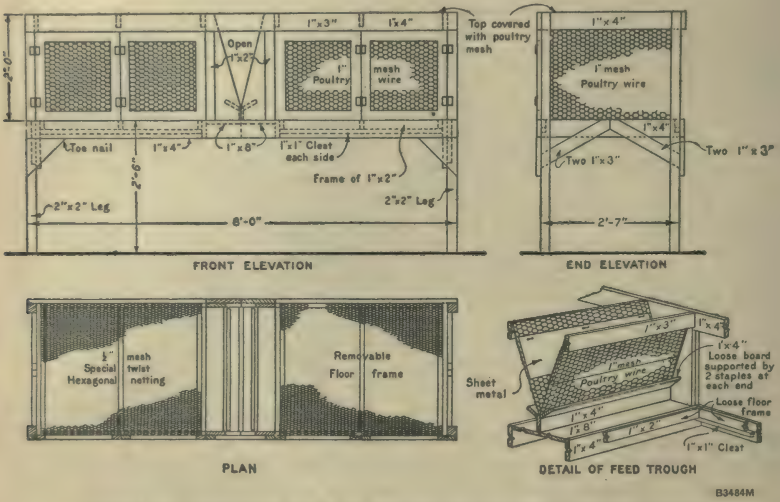

FIGURE 7.—Construction details for two-hutch unit of open-air wooden hutches.

Four 2- by 2-inch by 4½-foot legs.
Four 1- by 4-inch by 8-foot rails.
Six 1- by 4-inch by 2½-foot crosspieces.
Four 1- by 3-inch by 2½-foot crosspieces.
Eight 1- by 3-inch by 1½-foot braces.
Two 1- by 10-inch by 1-foot braces.
Six 1- by 8-inch by 2-foot feed sections.
Two 1- by 8-inch by 2½-foot feed sections.
Two 1- by 2-inch by 2-foot feed sections.
Three 1- by 4-inch by 2½-foot feed troughs.
Four 1- by 1-inch by 3-foot cleats.
Sixteen 1- by 2-inch by 1-foot 8-inch doors.
Six 1- by 2-inch by 2½-foot flooring.
Four 1- by 2-inch by 3-foot flooring.
6½ linear feet of ½-inch mesh, 30-inch special-twist hexagonal wire.
2 pieces of galvanized metal, 9 by 2½ feet.
4 pairs 1-inch hinges.
4 door fasteners.
6 linear feet of 1-inch mesh, 18-inch poultry wire.
18 linear feet of 1-inch mesh, 24-inch poultry wire.
8 linear feet of 1-inch mesh, 32-inch poultry wire.

NEST BOXES

The nest box (fig. 8) should be large enough to prevent crowding but small enough to keep the occupants warm by their own body heat. The top and bottom should be removable to facilitate cleaning.

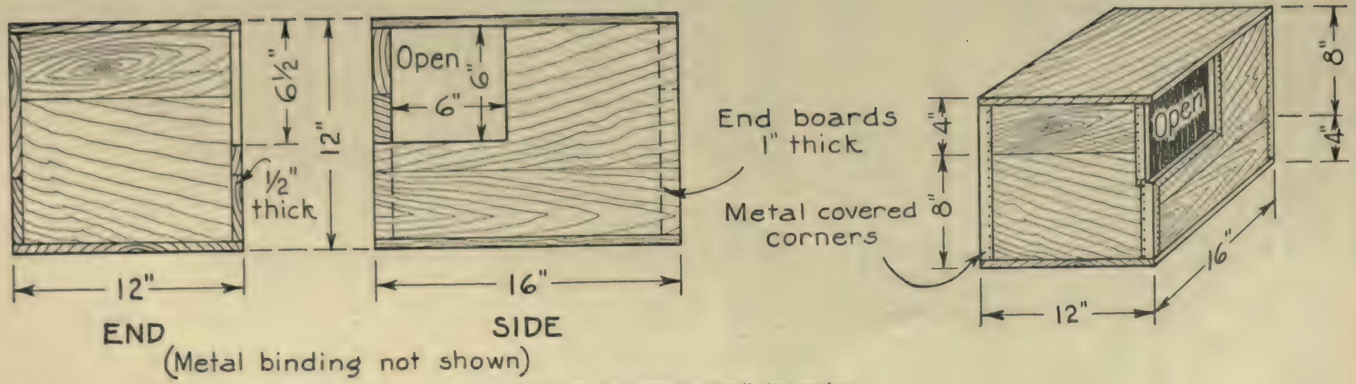

FIGURE 8.—Construction details for nest box.

DEVELOPING PENS

The primary purpose of developing pens is to afford places where weaned young can be carried with the minimum labor and equipment. The pens are particularly useful in housing young animals being grown out for breeders, fed out to a heavier market weight, or being retained a few days awaiting slaughter. Separate developing pens should be provided for bucks and does. As shown in figure 9, a developing pen can be constructed of the following materials:

Ten 2- by 4-inch by 10-foot uprights.
Nine 2- by 4-inch by 8-foot uprights.
Two 4- by 4-inch by 10-foot uprights.
Four 2- by 4-inch by 10-foot knee braces.
Nine 2- by 4-inch by 8-foot corner braces and headers.
Twelve 2- by 6-inch by 14-foot roof framing.
Two 2- by 6-inch by 12-foot roof framing.
Two 2- by 4-inch by 12-foot roof framing.
Eight 2- by 4-inch by 14-foot rails.
Twelve 1- by 6-inch by 14-foot baseboards and gates.
Three 2- by 4-inch by 8-foot gates.
Three 1- by 4-inch by 6-foot gates.
Two 2- by 4-inch by 14-foot partitions.
One 1- by 6-inch by 14-foot partition.
140 linear feet of 1-inch-mesh, 48-inch poultry wire.
3 pairs 4-inch strap hinges.
3 fasteners for gates.
22 sheets 26-gage galvanized metal roofing, 2½-inch corrugations, 2 feet 2 inches by 6 feet.
22 sheets same material 8 feet long.

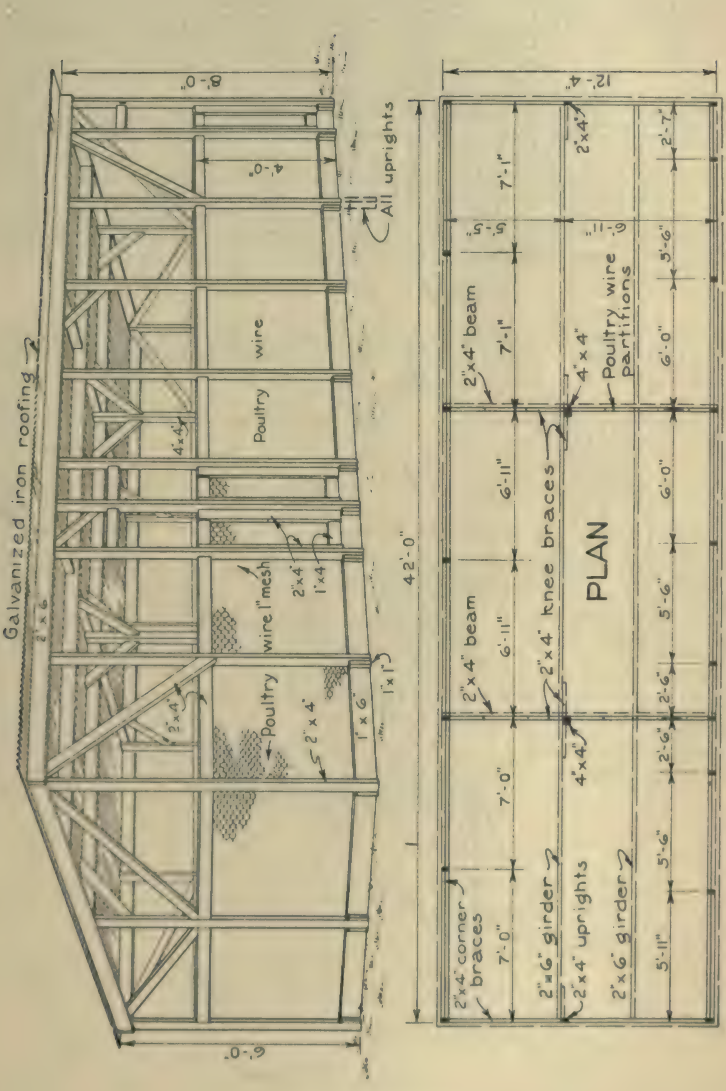

FIGURE 9.—Construction details for developing pen.

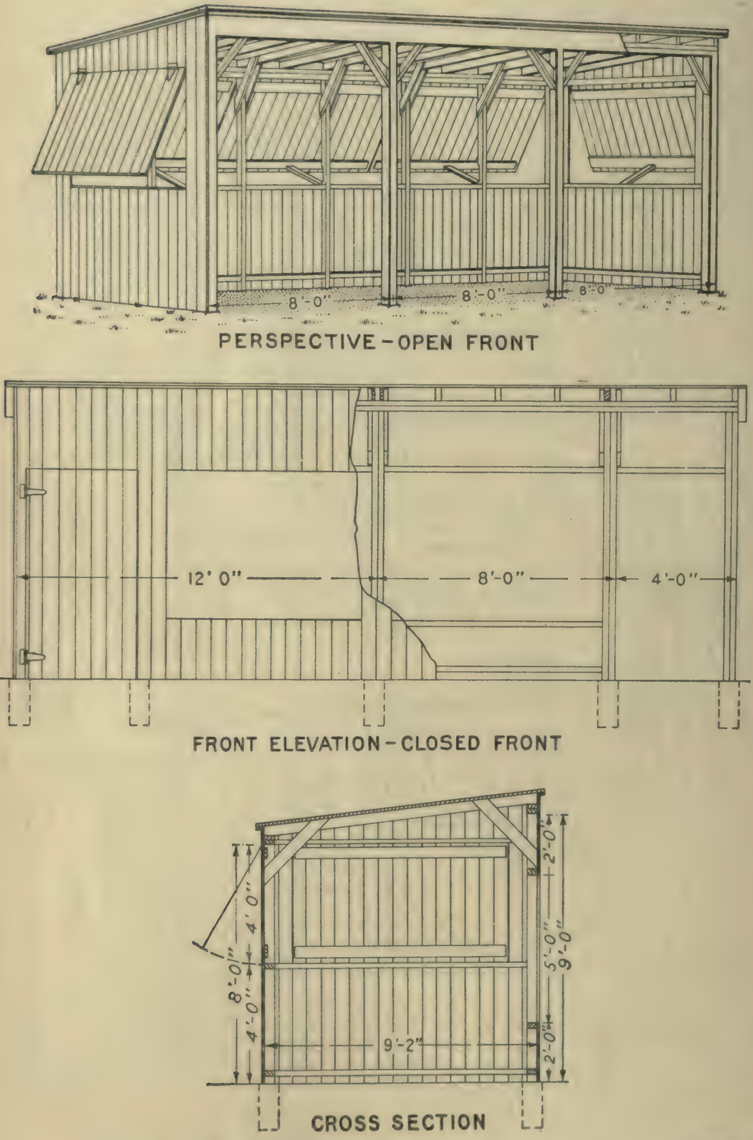

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FIGURE 10.—Construction details for rabbit house.

SHELTERS

Rabbit shelters or houses accommodating 50 to 100 breeding animals are preferable to larger ones, for in smaller groups rabbits are less likely to contract disease, and outbreaks are more readily controlled when the animals are kept in smaller units. The rabbit house shown in figure 10 can be constructed of the following materials:

- One-third of a cubic yard of concrete for post footings.
- Eight 2- by 4-inch by 9-foot posts.
- Nine 2- by 4-inch by 8-foot posts.
- Eighteen 2- by 4-inch by 8-foot plates and girts.
- Six 2- by 4-inch by 10-foot end girts.
- Thirteen 2- by 4-inch by 10-foot rafters.
- Fourteen 1- by 6-inch by 3-foot braces.
- Sixty 1- by 6-inch by 8-foot tongue-and-groove sheathing (rear).
- Forty 1- by 6-inch by 9-foot tongue-and-groove sheathing (ends).
- Two 1- by 8-inch by 12-foot rear facias.
- 280 feet board measure roof sheathing.
- 70 linear feet 1- by 1-inch material for under edge of roof.
- Prepared roofing for 260 square feet.
- 6 pairs 6-inch T hinges.

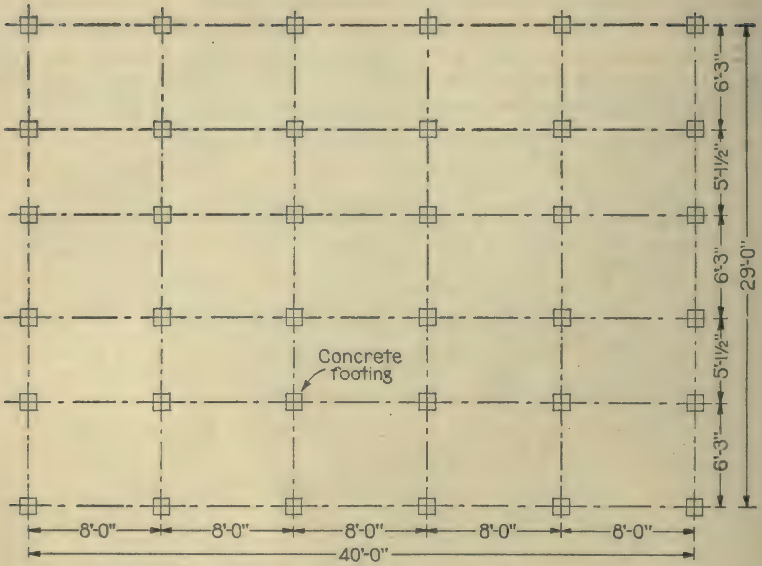
For open-front shelter add the following:

- Six 2- by 4-inch by 3-foot braces.
- Two 1- by 8-inch by 12-foot facias.
- Fourteen 1- by 4-inch by 9-foot post casings.

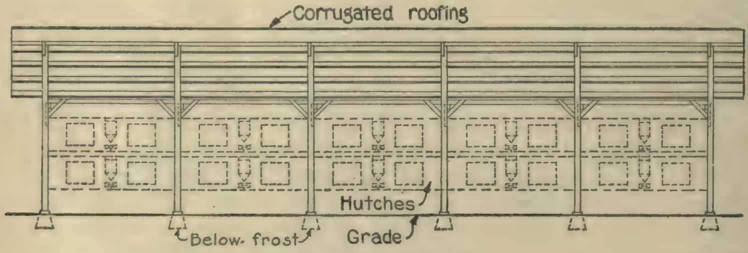
For closed shelter add the following:

- Two 2- by 4-inch by 9-foot posts.
- Seven 2- by 4-inch by 8-foot girts.
- Twenty 1- by 6-inch by 10-foot tongue-and-groove sheathing.
- Thirty-two 1- by 6-inch by 5-foot tongue-and-groove sheathing.
- Six 1- by 6-inch by 3-foot braces.
- 2 pairs 6-inch T hinges.

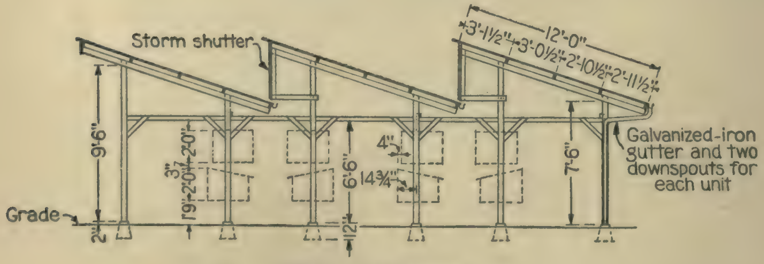
The rabbit shelter for which construction details are shown in figures 11 and 12 (see also fig. 3) has a distinct advantage in that additional sections can be added as needed. A concrete floor may be provided with gutters so situated that it can be readily washed clean. Where a corrugated metal roof makes the shelter too hot, composition shingles or rolled roofing may be laid over solid sheathing, the 2- by 4-inch rafters in such cases being placed on centers at 2-foot intervals to support the sheathing. Enclosing three sides or making other adaptations for climatic conditions may also be necessary. Materials needed for the shelter are listed on page 18.



FOUNDATION PLAN



FRONT ELEVATION



SIDE ELEVATION

FIGURE 11.—Construction details for rabbit-hutch shelter. (Prepared by Bureau of Agricultural Engineering.)

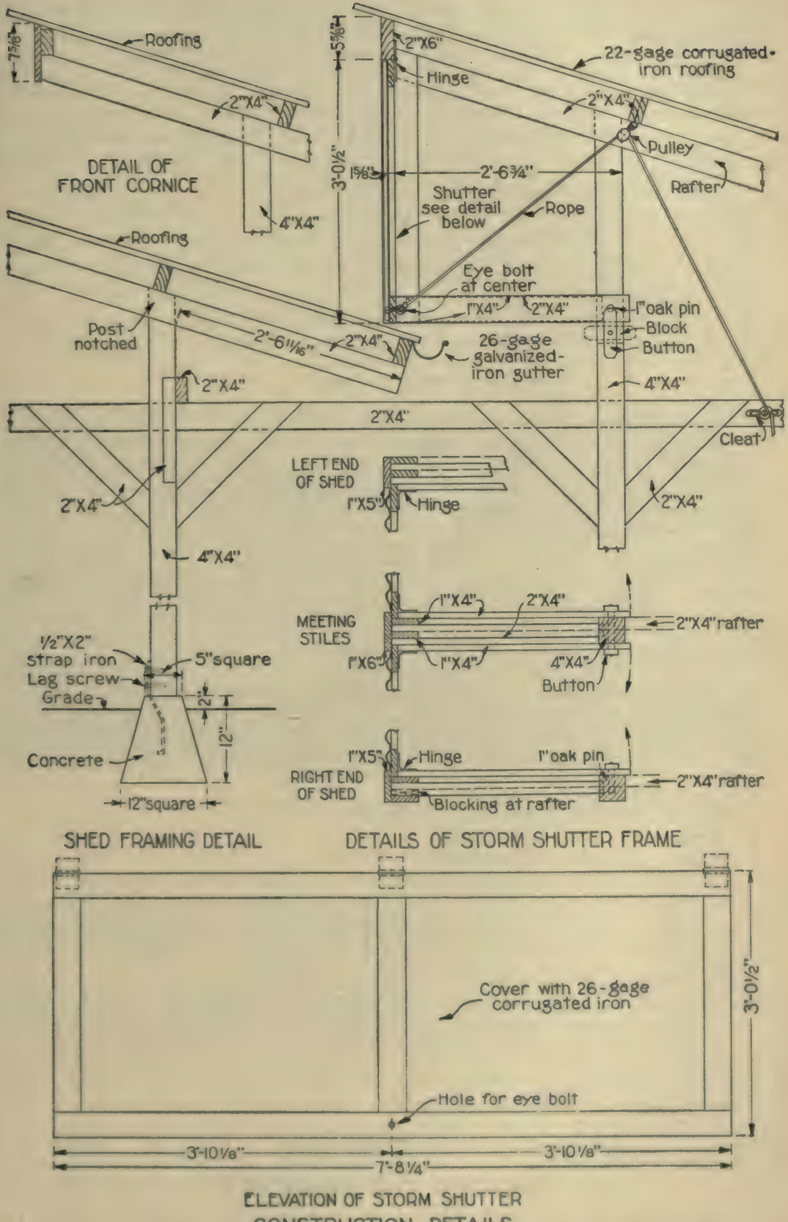


FIGURE 12.—Additional details for rabbit-hutch shelter. (Prepared by Bureau of Agricultural Engineering.)

BILL OF MATERIALS FOR RABBIT-HUTCH SHELTER

5 sacks of cement, three-eighths of a cubic yard of sand, and three-fourths of a cubic yard of gravel for 0.8 cubic yard of concrete for post footings. (Use 1 part Portland cement to 2 parts of sand and 4 parts of gravel. In localities where frost action is a consideration the footings should be placed below the frost line and be 8 by 8 inches in cross section. If the footings are 8 by 8 inches by 2 feet 8 inches the following materials will be needed: 10 sacks of cement, three-fourths of a cubic yard of sand, and 1½ cubic yards of gravel. Precast footings cost less than those cast in place.)
Thirty-six ¼- by 1½- by 16-inch strap irons, one end drilled for two ⅜-inch lag screws.
Seventy-two ⅜- by 4-inch lag screws.
Eighteen 4- by 4-inch by 10-foot posts.
Eighteen 4- by 4-inch by 8-foot posts.
Three 2- by 4-inch by 14-foot crossties.
Twelve 2- by 4-inch by 12-foot crossties.
Seven 2- by 4-inch by 16-foot longitudinal ties.
One 2- by 4-inch by 8-foot longitudinal tie.
Ninety 2- by 4-inch by 2-foot knee braces.
Eighteen 2- by 4-inch by 12-foot purlins.
Twenty-six 2- by 4-inch by 16-foot rafters.
Thirteen 2- by 4-inch by 8-foot rafters.
Five 2- by 6-inch by 16-foot facias.
Two 1- by 8-inch by 16-foot facias
One 1- by 8-inch by 8-foot facias.
Eight 1- by 5-inch by 3-foot facias.
Four 1- by 6-inch by 3-foot facias.
Twelve 2- by 4-inch by 2-foot 6-inch struts.
Twenty 1- by 4-inch by 2-foot 9-inch hangers.
Twenty-four 1- by 4-inch by 3-foot 3-inch hangers.
Seven 1- by 4-inch by 12-foot blocks.
Thirty 1- by 5-inch by 8-foot pieces for shelter frame.
Twelve 1-inch oak pins 7 inches long.
One 1- by 2-inch by 10-foot piece for buttons.
Fifty 3- by 3-inch hinges with screws.
20 round-head screws 2½ inches long with washers for holding buttons.
Ten ⅜- by 1½-inch eyebolts, 1-inch eye and nut.
10 screw eyes (1-inch eye) or heavy staple.
10 swivel pulleys for ¼-inch rope.
Ten 4-inch cleats for ¼-inch rope, with screws.
90 linear feet ¼-inch sash cord.
120 linear feet 4-inch gutter with hangers.
38 linear feet 3-inch downspout.
6 turnouts for 3-inch downspout.
Twelve 90° bends for 3-inch downspout. (All gutters and spouts to be of 26-gage galvanized metal.)
40 pieces corrugated roofing 3 feet long, 26 inches wide for shutters. (Plain galvanized metal, weather-resistant wall board, or ⅜-inch tongue-and-groove ceiling could be used in place of corrugated metal.)
66 pieces corrugated roofing, 7 feet long, 26 inches wide.
66 pieces corrugated roofing, 6 feet long, 26 inches wide. (Roofing to be 24-gage, 2½-inch corrugations, and heavily galvanized; nails for securing roofing should be rust-resistant, providing security against leaks.)
18 pounds 16-penny common nails.
2 pounds 8-penny common nails.
1 pound 8-penny finishing nails.
5 pounds 10-penny common nails.
10 gallons of paint for woodwork (three coats).

STOCKING THE RABBITRY

The beginner in rabbit raising may start with young rabbits just weaned, or with mature animals. When young are used for foundation stock, the breeder has an opportunity to become acquainted with his animals and their habits before they reach the production stage. In selecting stock it is always to be remembered that rabbits are raised for both meat and fur, and under ordinary circumstances meat is the more important.

When purchasing breeding stock, it is better to deal directly with reliable breeders; brokers handling live rabbits are seldom able to vouch for the conditions under which their animals were produced. Reliable breeders will always stand behind the stock they offer and will give references. National, State, and local rabbit-breeders' organizations can furnish names and addresses of breeders from whom stock can be purchased, and further inquiries can be made of local chambers of commerce and better-business bureaus. It is contrary to the policy of the Department of Agriculture to vouch for the integrity or the financial standing of any individual or company.

The essential requirements of good foundation stock are: (1) Health and vigor, (2) ability to reproduce profitably, and (3) type and conformation consistent with ability to produce marketable offspring of high quality and the desired size. Animals deficient in vitality, even though free from disease, cannot be expected to produce young profitably.

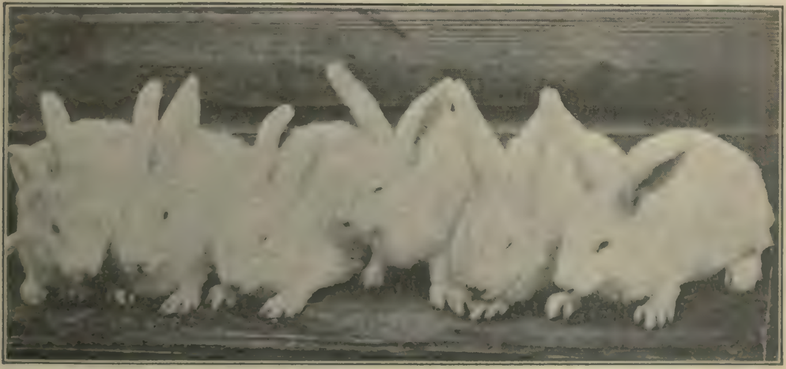


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FIGURE 13.—A litter of healthy, vigorous young rabbits of good conformation.

COMMON BREEDS

Although the American Rabbit and Cavy Breeders Association has set up 51 different standards for breeds and varieties of rabbits, the beginner should make his selection from only 6 or 8 breeds. Fine distinctions will only be confusing to him, and from a utility standpoint a large number of breeds and varieties will be a handicap to the proper development of his own business and also to that of the industry. The rabbits best suited in size and conformation to the commercial production of meat and fur are the medium and larger breeds, such as Flemish Giant, New Zealand, American, Beveren, French Silver, and Chinchilla. White rabbits that are satisfactory meat producers are most desirable (fig. 13) because their fur usually brings higher prices in the large markets. The preference among such white breeds is largely a matter of personal choice.

CHINCHILLA RABBITS

The Chinchilla rabbit, a comparatively new breed, especially in the United States, has been widely heralded as a "fur rabbit", perhaps more than any other breed, and many exaggerated and misleading statements have been made regarding the value of its fur and the large profits to be derived from the sale of the pelts. This has had a tendency to create a false impression and has led many to invest large sums in breeding stock, only to learn that the claims made were exaggerated. The color of the pelt of the Chinchilla rabbit is especially attractive, and this is responsible in large measure for the widespread popularity of the breed. The price paid for skins by the large fur buyers, however, is not sufficient to justify many of the assertions that have been made or to enable one to engage in breeding these rabbits for their fur alone; they must be bred for both meat and fur. It is important that breeders pay special attention to commercial rather than fancy qualities. The fur should be a rich, even, uniform shade of soft, bluish gray., free from any brown or rusty tinge, and interspersed with long hairs (commonly called guard hairs) tipped with jet black and so arranged as to give a wavy effect. The chest and flanks may be a lighter shade, but an even, harmonious blending of color in all sections is desirable. The underfur at the base should be slate blue and the intermediate color ashy gray, merging into pearl gray, with black and white at the ends of the hairs. The belly should be bluish white on the surface, and its under color should be a deep, rich blue.

ANGORA RABBITS

The Angora rabbit, much advertised by promoters as a source of fabulous fortunes, is too small for profitable meat production, and its skin has little value in the fur trade. It does, however, produce a wool from 5 to 8 inches long within a year's time, and when the commercial practice of shearing four times a year is followed the wool attains a length of 2½ to 3½ inches each quarter. A mature animal not suckling young will shear on an average about 12 ounces a year. The wool is reported to be unusually warm and light when made into garments, but owing to its cost and its fluffy nature it is used mostly in conjunction with other fibers. Conducted carefully and conservatively, Angora raising has a proper place in our agriculture, but such fortunes as those promised by some promoters cannot be realized from it. This kind of propaganda has already done considerable damage to the business.

In general Angora rabbits are cared for in the same way as are other rabbits, but in addition considerable labor is required to keep the wool on the rabbits brushed out or blown free from matting and foreign material. Pregnant does should not be sheared over the belly, for they use some of this wool in making nests.

FEEDING PRACTICES

KINDS OF FEED

To produce good meat and fur, rabbits must be furnished wholesome feeds that are relished and at the same time are available at reasonable cost. Proper feeding is also an important factor in keeping the animals healthy and thereby lessening losses from disease. Rabbits have been fed all kinds of grains and mashes, various hays, and green stuff ranging from tubers to lawn clippings. The principal concentrates fed are barley, oats, and wheat (rolled or ground): cracked corn, kafir, linseed meal, peanut meal, and soybean meal. Other feeds often used are wheat bran, rice bran, beet pulp, and molasses. Alfalfa, clover, soybean, oat, and timothy are the principal hays fed. Of these, alfalfa and clover are used most extensively. High-quality alfalfa or other leguminous hay constitutes an important part of the rabbit ration. In fact, the work carried on at the United States Rabbit Experiment Station shows that the best results are obtained with breeding does when about 60 percent of the ration is made up of good-quality legume hay.

NUTRITIVE RATIOS

Economical and profitable feeding can best be obtained by balancing rations according to the three nutrients of feeds—fats, carbohydrates, and proteins. Tables showing the nutrients for various feeds are included in texts on principles of feeds and feeding. Fats and carbohydrates are fat-producing and energy-producing constituents, fats being two and one-fourth times more valuable in this respect than carbohydrates. Protein develops lean tissue, hair, and connective tissue. Corn, wheat, barley, and oats are especially rich in fats and carbohydrates. Alfalfa hay, clover hay, peanut meal, soybean meal, and linseed meal are rich in protein and also are palatable to rabbits, but timothy hay, wild hay, and other carbonaceous roughages are somewhat unpalatable.

Since feeds that are richest in protein are the most expensive, the relative proportion of this nutrient to the combination of fats and carbohydrates should receive primary consideration. This proportion for any feed, known as the nutritive ratio, is found by multiplying the percentage of digestible fats by 2¼, adding to this the percentage of digestible carbohydrates, and then dividing this sum by the percentage of digestible protein, as in the following formula:

$$\text{Nutritive ratio} = \frac{\text{Digestible fats } (\%) \times 2\tfrac{1}{4} + \text{ digestible carbohydrates } (\%)}{\text{Digestible proteins } (\%)}$$

In stating nutritive ratios, protein is always expressed as 1.

A relatively narrow nutritive ratio—that is, a ratio of 1:3.8 or less—seems to give most satisfactory results for does suckling young. A recent analysis at the Rabbit Experiment Station shows, for instance, that rabbit's milk contains more than twice as much total solids as cow's milk, about four times the protein and fat, and three times the ash, but only one-sixth as much lactose.

MINERALS AND VITAMINS

Little definite information is available concerning the mineral requirements of rabbits, but unquestionably a mineral deficiency is less likely if the animals are supplied a wide variety of feeds, including green stuff, and if 60 percent of the ration is good-quality alfalfa hay. Since feeds from different sections have varying mineral contents, odorless bone meal to the extent of 1 percent of the grain ration may be added, at little cost, to insure an adequacy of minerals at all times.

These feeding practices will also usually supply vitamins in the required variety and quantity. For this purpose it is especially important that the alfalfa hay be bright green and leafy and that lawn clippings, freshly cut alfalfa, garden vegetables, or other green feeds be included in the daily ration.

SUGGESTED RATIONS

Of the total feed for does nursing young, legume hay and such succulent feeds as carrots, green alfalfa, wild oats, and green barley may comprise 60 percent—45 to 50 percent of legume hay and 10 to 15 percent of succulent feeds. When no succulent feeds are available, legume hay should constitute the full 60 percent. The remaining 40 percent may consist of either of the following grain mixtures:

No. 1

40 pounds rolled oats.
25 pounds wheat bran.
20 pounds rolled barley.
14 pounds peanut meal (unadulterated).
1 pound odorless bone meal.

No. 2

25 pounds rolled wheat.
25 pounds coarsely ground yellow corn.
25 pounds rolled oats.
24 pounds soybean meal.
1 pound odorless bone meal.

Both of these concentrate mixtures give the nutritive ratio of 1:3.89. As this ratio is identical with that of alfalfa hay, the quantity of hay supplied with these mixtures will not affect the nutritive ratio of the total feed. Peanut meal and soybean meal may be used interchangeably, but if linseed meal is substituted, the quantity of meal in the mixture should be increased 60 percent in order to keep the nutritive ratio the same. In other words, the value of linseed meal as a protein supplement is five-eighths that of the same quantity of peanut or soybean meal.

Salt should also be provided, either by keeping a salt spool in the hutch or by adding a pound of salt to a 100-pound grain mixture.

The same feeds or combinations of feeds and the same feeding methods should be continued without sudden changes. This does not mean that the same kinds of feed should be given during every season of the year, but rabbits may be "thrown off their feed" by such radical changes as occur when a breeder suddenly adopts a new ration on learning of another's success with it.

PREPARATION OF FEED

Grains for rabbits should be reasonably soft and crumbly, but never hard or in the form of powder. It is preferable to use crushed or rolled barley, oats, and wheat. Grain mixtures may be fed either dry or moist. If a moist mixture is desired, a small quantity of scalding-hot water may be added and thoroughly mixed with the grain until the fine particles adhere to the larger grains and the whole is of a crumbly consistency. The mixture should never be moist enough to be soggy or sticky; to avoid this, use scalding-hot rather than cold water.

Another method of moistening the grain mixture is to soak whole grains of wheat, oats, or barley overnight or from one feeding to another, then drain the water from the grains, add the rest of the dry-grain mixture, and thoroughly mix it with the soaked grain.

If alfalfa is fed whole, a considerable quantity will be wasted, because the rabbit will pull out a stem, eat part of it, and drop the rest. To avoid this wastage the general practice is to cut the hay into 3- to 4-inch lengths before feeding. A convenient home-made equipment for this purpose is shown in figure 14, the use of which eliminates the dust and the leaf shattering incident to chopping with an ordinary green-feed cutter.

QUANTITY OF FEED AND FREQUENCY OF FEEDING

Many breeders feed their rabbits too much. Giving a limited quantity of grain and hay at each feeding is more satisfactory than permitting access to feed at all times. Rabbits eat more at night than during the day and, therefore, it is advisable to feed the bulkier portion of the ration at night. Feeding grain in the morning and hay in the evening is satisfactory for young growing stock, resting does, and bucks. Does that are nursing require additional grain in the evening. The ration for each rabbit depends on the season and on the animal's age, appetite, and condition. Adult rabbits should be fed fairly heavily just before and during the breeding season, so that they may be vigorous. Nursing does and young rabbits that have been weaned should be fed liberally. The appetite is a good index to feeding. The quantities fed should be regulated, so that the rabbits may remain active and show eagerness to eat at mealtime.

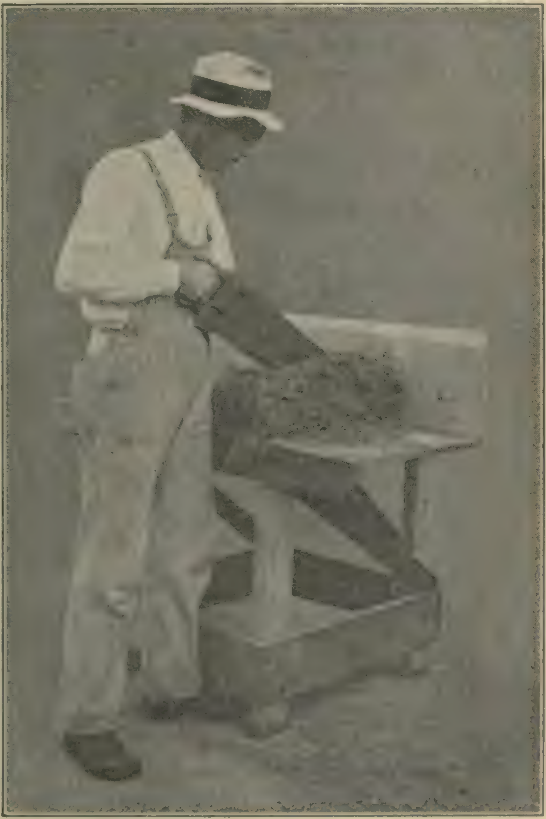

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FIGURE 14.—A cheap and convenient device for cutting hay into short lengths.

The season should be given due consideration in feeding operations. It is well to change the plan of feeding in summer, because rabbits need less food in hot weather. The animals should be watched closely, and if they begin to show a disinclination to eat, the quantity of feed supplied should be reduced. During the heat of the day they show little interest in concentrated rations. Green feeds are especially relished then, and these add freshness to the diet.

The beginner, instead of guessing or estimating, will do well to follow a rule in determining the quantity of feed to give his rabbits daily. A good general rule is to supply 2½ to 6 ounces of hay and 1 to 2 ounces of grain daily to mature does without young, to mature breeding bucks, and to growing young stock of both sexes. Does that have just kindled may receive a slight increase in the grain and hay ration to supply their requirements for milk production, and as the young grow and develop, further increases in the grain and hay should be made.

Following a good system enables the rabbit breeder not only to feed properly and economically, but also to determine in advance the quantities of feed required for any period. The Rabbit Experiment Station has found that when hay constitutes 60 percent of the ration, approximately 300 pounds of feed a year are required to maintain each doe and raise her four litters to 8 weeks of age. Similar experiments at the station have shown that approximately 30 pounds of barley or oats and 115 pounds of alfalfa hay are required annually to keep a mature New Zealand buck at a satisfactory breeding weight.

BREEDING

The age at which the different kinds of rabbits may be bred varies with the time required by them to attain full size. In the utility breeds this is usually 7 or 8 months; in small breeds it may be 5 or 6 months. Successful matings may be made at any time within the breeding period, which usually lasts 13 to 15 days. The period of gestation is 31 days. Each doe should be bred four times a year, allowing 1 month for gestation and about 2 months to raise the young. It is not advisable to keep rabbits for breeding purposes after they are 4 years old.

The number of young in a litter varies greatly. Litters usually number 7 or 8, but they may contain 12 or more. When large litters are produced, however, only 7 of the best should be saved, unless the doe is an exceptionally good mother. If several does are bred at about the same time, it is possible to transfer some of the young from one to another, after proper marking for future identification.

Each breeding doe must have a separate hutch for herself and her young, and the buck must be kept by himself. One buck is sufficient for 10 breeding does. At mating time the doe should be taken to the hutch of the buck. The buck should never be put in the doe's hutch. When the doe is brought to the buck she should be held gently and quieted to prevent undue excitement. After service, the buck will usually fall over backward or on his side, and the doe should then be removed to her own hutch. If the doe does not voluntarily accept service within 4 or 5 minutes, she should be taken away and returned again the next day. A little practice will teach the operator the proper method of restraining the doe without interfering with voluntary acceptance of service. A buck and a doe should not be left together for long periods, as they are likely to fight and injure each other.

An accurate record of the date on which each doe is bred should be kept. A few days before the young are expected, the hutch should be carefully cleaned, and the nest box, containing plenty of hay or straw, placed inside. The doe will make her own nest. A day or two after the young are born she may be removed from the hutch a few minutes in order to examine the nest, to determine the number of young in the litter, and to remove any dead ones.

As too frequent handling of new-born young may cause the doe to disown or even to kill them, no other disturbance is advisable until they are large enough to come out of the nest and run about the hutch. At this time the nest should be cleaned and fresh straw provided.

The young may be weaned when about 6 weeks old, but it is best to leave them with the doe until they are 8 weeks old. Males and females that are not marketed should be placed in separate hutches. A considerable number of young does may be kept together in the same open run until ready for marketing or breeding (fig. 15). The same is true of young bucks, though any that are unusually quarrelsome must be separated from the others.

IMPORTANCE OF HEREDITY

Certain fundamental principles of breeding evolved from years of scientific study and observation should be noted carefully. At present the evidence indicates that environment has little to do directly with improvement of animal form, and that proper care and management practiced over several generations have no cumulative effect in developing a better breed of rabbits. Good feeding and care do, however, have the indirect value of providing a basis on which to select individual rabbits that because of their heredity will respond most satisfactorily to such care and management.

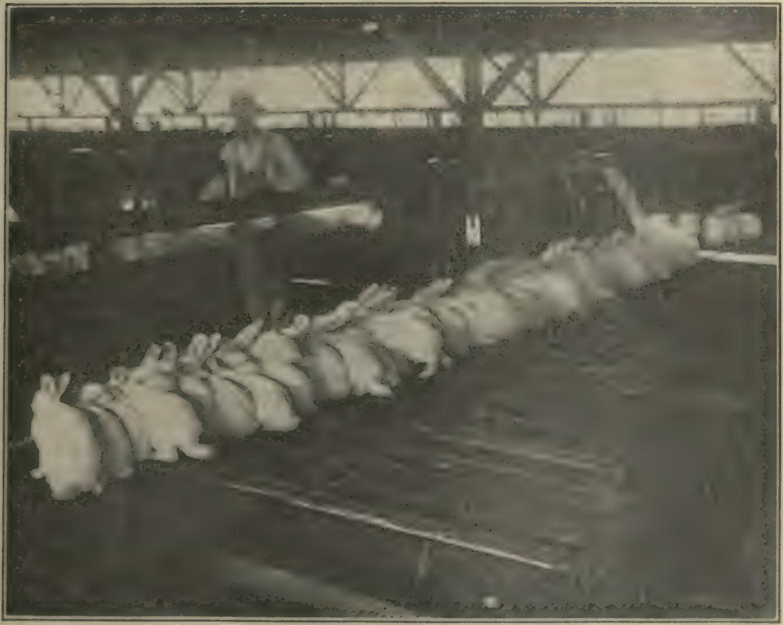

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FIGURE 15.—Young rabbits being kept together until ready for marketing. These young are uniform in size and other desirable qualities.

If improvement in rabbits is brought about, it must come chiefly through hereditary factors that are transmitted through the germ cells. Effort, therefore, should be concentrated toward improvement by so mating the animals as to recombine these factors in more desirable forms.

The facts in brief are: Thousands of factors, called genes, determine the inheritance of each individual. These are collected into groups like beads on a string or like little packets. The groups are called chromosomes, and the number of these in each cell is definite for each species. In the rabbit the number of chromosomes is 44, made up of 22 pairs. One of each pair comes from the father and the other from the mother.

The numerous breeds of rabbits, differing in size, color, and form, have resulted from various more or less stable combinations of these chromosomes. Frequent new combinations account for the off-type individuals cropping out within a breed and explain also the extreme variability noticeable in the newer breeds of rabbits as compared with older breeds that have eliminated most of the variable factors. The chromosomes frequently exchange genes, and this regrouping permits various recombinations, which are at once the hope and the despair of animal breeders. Without such variations there is no chance of improvement; with them there is no assurance of fixing a type without constantly selecting animals with desirable factors and discarding those with undesirable factors.

Another form of variation, though less common and less important from the breeder's standpoint, has produced types of some of the most important commercial varieties of rabbits. This is known as mutation, and an example is the rex type, in which the guard hairs are either shorter than the underfur or entirely absent. Rex is recessive to the normal coat, and consequently a normal-haired rabbit may possibly be a carrier of rex. Any breed can be "rexed" within three generations by proper matings, if a sufficient number of rabbits are produced. When the offspring of a normal-haired rabbit and a rex-appearing animal are bred together, 25 percent will be pure rex, and if a New Zealand white and a Castorrex are mated, about 1 out of 16 of the offspring will be both white and rex. One of the breeding experiments conducted by the Bureau of Biological Survey at the Rabbit Experiment Station has for its purpose the development of a white rex breed that will have the meat qualities of the older and better established meat breeds of rabbits.

Woolly, or long hair, is another mutation in rabbits. This, however, unlike the rex, is an undesirable trait. Woolly in rabbits is also a recessive, and consequently any of the rabbits that one suspects has the woolly character can be tested by mating it with a woolly appearing rabbit (and therefore pure for this character). If any young rabbits produced from this mating show the woolly character, one can be certain that the animal being tested is a carrier of woolly even though it is normal haired. Neither should be used in breeding.

SELECTION

Selection of the young of individuals or the individuals themselves that have splendid production records, called mass selection, may appear to be an excellent breeding policy, yet practice has shown that once the animals are on a fair production basis the productivity of a rabbitry may actually decrease when mass selection is practiced. The higher the plane of development, the less efficient this procedure becomes. A high-producing doe may herself carry the dominant genetic factors for high production, but together with these she may also carry undesirable recessive factors that cannot come to expression in the doe herself but may be transmitted to her offspring. High-producing ability in the doe and the transmittal of this ability to all her progeny are different things.

A progeny test surmounts this difficulty. Briefly, a progeny test is the selection of those animals for breeding the majority or all of whose sisters are high and efficient producers. Not only is such an animal a high producer, but when properly mated it consistently passes this characteristic to the offspring. The progeny may be safely considered to have these factors for efficient breeding in a more or less pure state. All rabbit breeders should adopt the progeny test as a basis for the selection of their breeding stock.

INBREEDING

The United States Department of Agriculture receives many letters inquiring whether inbreeding is desirable; that is, mating rabbits that are closely related. The Department's answer is that the average rabbit raiser should not attempt inbreeding for the following reasons:

Inbreeding knows no favorites. It will intensify poor qualities just as readily as it will good qualities.

The average breeder has not the ability to judge exceptional qualities in his breeding rabbits, nor does he usually have the necessary knowledge of the previous history of his stock to know what results to expect.

Since the rabbits of the average breeder are usually of mixed inheritance, inbreeding such animals will always result in a variety of progeny.

Inbreeding is not harmful in itself, but it is sure, rapid, and effective in analyzing the genetic structure and make-up of living forms. It will always remain a most potent procedure in developing and improving any breed of rabbits, and, in fact, no procedure other than a close mating with rigid selection can be relied upon unfailingly to fix a type. Inbreeding is, however, a 2-edged sword, with which the ordinary rabbit raiser cannot afford to play. Discarding all undesirable forms, which is a necessary part of inbreeding, requires courage and considerable financial backing.

It would be a good thing for each rabbit-breeders' association to finance in some way the inbreeding of 2 or 3 of the best strains within each breed, with the intention of ultimately crossing these pure strains, and thereby developing a still better breed. This undertaking would be too expensive for the individual breeder, yet it has great potential value for every breeder. Breeders' associations could well finance such programs for the benefit of all the members.

MANAGEMENT PRACTICES

Just as in any other business, success in breeding rabbits depends upon efficient management. First of all the rabbit raiser should become thoroughly acquainted with his animals—their characteristics and behavior, their likes and dislikes. Consideration for the welfare of animals is always necessary for success in raising them. Proper arrangement of equipment, hutches, and buildings is also essential to efficient management.

HANDLING RABBITS

Care should be exercised in handling rabbits. In picking them up, the breeder should grasp the loose skin over the shoulders in one hand while placing the other hand under the animal as a support (fig. 16). Rabbits should never be picked up by the ears or the feet. When it is necessary to carry them any distance, it is best to place them in a carrying box.

MAKING A WORK SCHEDULE

As labor is one of the principal factors affecting success in raising rabbits, such operations as feeding, cleaning, handling, and marketing should be carried on in accordance with a definite plan or program. By having a definite time for each task and performing each one in a practical manner, one person should be able to care for approximately 250 producing does, the requisite number of breeding males, and the young replacement stock. In deciding upon a work schedule, the rabbit raiser will have to be governed by his own peculiar circumstances, but once his program is adopted it should be carried out regularly.

CARE OF STOCK IN HOT WEATHER

In almost all sections of the United States the high temperatures require some changes in the general care and management of rabbits in summer. Adequate shade should be provided to protect the animals during the hotter parts of the day, but rabbits should not be placed where they are totally excluded from sunlight during the cooler hours. Good circulation of air throughout the rabbitry is a necessity, and an abundant supply of water should be available at all times.

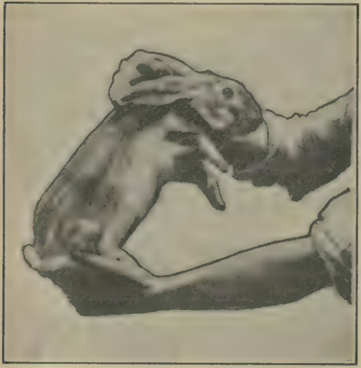
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FIGURE 16.—The proper way to handle a rabbit.

The first hot spell of the season is usually the period when the animals need most careful attention. They have not had time then to adjust themselves to the heat and are therefore easily overcome. There should be a thermometer hung for convenient reading in the rabbitry. When the temperature reaches 95° F. the rabbits should be watched carefully for evidence of distress, and in any case when the thermometer registers higher than 97° some precautions here recommended should be taken.

During hot spells rabbits can be protected by placing in the hutch an ordinary burlap sack folded and soaked in water. This makes a cool cushion. Hanging dampened burlap sacks around the hutch is also effective, and the rabbitry can be cooled by sprinkling the ground immediately surrounding the hutches. If even these methods are impracticable, it is advisable to provide small temporary pens in shady places on the ground. Animals taken from the hutches will find these pens refreshing during periods of excessive heat.

In parts of the country where high temperatures prevail throughout the summer, a sprinkler system is a worth-while permanent equipment for the rabbitry. There are various types of such systems on the market, and in many cases ordinary lawn sprinklers will serve satisfactorily. In general, the result desired is to have the finest possible spray of water completely cover the area in which the hutches are located. This spray should fall from a distance of 5 to 6 feet above the hutches. Throughout the intense summer season it should be in use almost daily during the hotter portion of the day.

Does that have recently kindled or those about due to kindle will be most quickly affected by hot weather. They should be watched for signs of uneasiness, decided panting, or heavy breathing, and any so affected should be removed from the hutch and placed on the ground in the shade. Temporary pens should be handy for such occasions.

Litters of newly born young also need special attention. Failure to provide for the young on very warm days is often responsible for many deaths. Nesting material should not be allowed to become matted in the nest box as it then prevents free circulation of air. Burlap sacks dampened, folded, and placed under the nest boxes will help keep the young cool. If the boxes have removable covers, these should be taken off, at least during the greater part of the day. They may be replaced for the night.

DOES THAT DESTROY YOUNG

Individual does frequently destroy and eat their young. This abnormal appetite is sometimes due to feverishness caused by constipation following kindling, and undue handling or excitement during kindling may also result in such destruction. Proper feeding and handling during pregnancy will do more than anything else to prevent this tendency. A valuable doe that destroys her first litter should be given another chance, but if she continues the practice with subsequent litters she should be sold for meat.

DETERMINING AND SEPARATING THE SEXES

Male and female rabbits should not be kept in the same hutch or pen. To ascertain the sex of the young, open the aperture just in front of the anal opening by pressing with the thumb and forefinger. In the buck the organ will protrude.

EAR MARKING

In order to keep records of ancestry and thus make scientific matings possible, it is necessary to identify each of the breeding rabbits. Tattooing the ears has proved to be the most satisfactory method; it is permanent and does not disfigure the ears. Instruments for the purpose can be bought from biological supply houses. A good type is one in which separate lugs, with a series of numerals, can be inserted into a plierlike handle. Such an instrument perforates the inner surface of the ear at one operation. India or drawing ink is then rubbed into these small holes.

SANITATION

Rabbit breeders should always bear in mind that it is better to prevent diseases than to attempt to cure them. Most rabbit diseases are preventable, and this fact is of special importance because the causes of many are not definitely known. Losses may be avoided to a large extent by simple methods of cleanliness and management in maintaining health and vigor in the stock.

HUTCHES AND NEST BOXES

Keeping hutches, nest boxes, feed troughs, and water containers always clean will help prevent disease. It is essential, therefore, that they be so constructed as to be readily cleaned (p. 4). All refuse should be removed frequently rather than permitted to accumulate in the hutches or nest boxes. The droppings are a potential source of trouble because they may contain parasitic-worm eggs and disease germs. Feed troughs and water containers should be so placed that the rabbits cannot contaminate them with feces or urine.

Hutch floors should be constructed of ⅝-inch hardware cloth or of perforated metal flooring (p. 5), so as to permit the refuse to drain or drop to the ground. To facilitate cleaning, the nest boxes should be of the knock-down type (fig. 8).

RABBIT MANURE AS A BYPRODUCT

The proper use or the sale of rabbit manure may well be an important factor in the success of the rabbit industry. The character of food determines the richness of the manure in fertilizing constituents. Rabbits raised under intensive conditions are certain to produce a valuable fertilizer. The droppings may be collected and stored or immediately distributed on the land.

Care should be taken, however, in using rabbit manure on crops that are to be fed to rabbits. Where this practice is followed, advice should be obtained from State or Federal authorities regarding proper precautions for preventing parasitic or other diseases. A cheap and satisfactory method of sterilizing the manure is to place it in a wooden box connected with a steam jet. If coccidiosis is present in the rabbitry, the manure should not be put on any crops that will be fed to the rabbits.

TREATMENT OF DISEASE

Although maintenance of sanitary conditions and prevention of disease are thus functions of the rabbit breeder, treatment of disease calls for the services of a veterinarian. Special training is required for accurate diagnosis of disease and for administration of potent drugs, and usually the rabbit breeder is not equipped to do this sort of work.

As effective treatments are known at the present time for very few of the rabbit diseases, it is usually simpler and safer to destroy a few animals that are sickly than to attempt to treat them and run the chance of their spreading infection to healthy stock. This is especially true of animals with coccidiosis and snuffles. For further information on rabbit diseases and their treatment breeders may consult Farmers' Bulletin 1568, Rabbit Parasites and Diseases.

QUARANTINE

Infected animals that are to be treated should be isolated and housed in clean and disinfected quarters. The hutches from which they have been removed, their nest boxes, and their feed and water dishes should be cleaned and disinfected with a 3-percent compound cresol solution or a 5-percent carbolic acid or other suitable disinfectant.

Before newly acquired animals are placed in the rabbitry, they should be quarantined and examined thoroughly for any symptoms of disease. Special hutches for this purpose should be constructed and placed 50 to 100 feet from the place where the breeding stock is housed. Similarly, rabbits returning from shows should be kept separate from all other animals for 3 weeks. If they have become infected with disease it will usually become apparent in that time.

PREPARING PRODUCTS FOR MARKET

CRATING AND SHIPPING LIVE RABBITS

Rabbits in good condition, properly crated, and provided with food and water can be shipped almost any distance with safety, but it is best not to ship them in extremely hot or cold weather. Crates should always be comfortable, well ventilated, and furnished with bedding of straw or leaves, not sawdust. Only one animal should be placed in one compartment of a shipping crate. Animals to be in transit for 24 hours or less need no more attention than that required to supply a small quantity of feed and water at the beginning of the journey, but if the trip is long and the shipment large, greater supplies of feed and water will of course be needed, and it may be necessary to send along a caretaker. Plenty of fresh water should be accessible to the rabbits at all times. The same kinds of feed that they have been accustomed to eating in the rabbitry should be given them in transit.

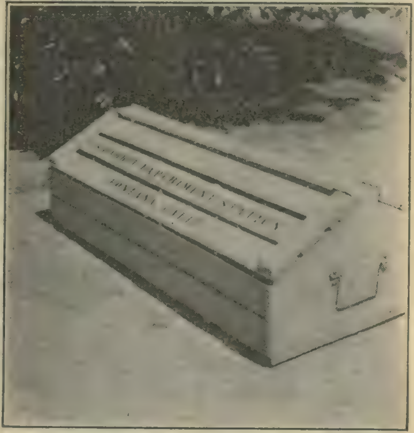
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FIGURE 17.—Crate for shipping live rabbits.

Although shipping crates can be made from packing boxes, it is not only good business but effective advertising to ship the rabbits in durable crates that are neatly built, light in weight, and attractive (fig. 17). The shipper should furnish ample space in each compartment and see to it that wire netting effectively prevents the rabbits from gnawing the wood.

When rabbits are shipped by express, a bag of food and a printed request to feed and water the animals once daily should be attached to each crate. Advice should be given against exposing the animals to sun or rain and also against placing the crates near steam pipes. The purchaser should be notified when the rabbits were shipped.

KILLING AND SKINNING

When rabbits are slaughtered in large numbers the neck is usually dislocated by holding the animal by its hind legs and giving its head a pull and a quick upward snap. This not only is a humane way of killing but also prevents struggling, which is apt to discolor pelts with blood. The carcass is then suspended on a hook inserted between the tendon and the bone of a hind leg just above the hock, and either the jugular vein is cut or the head removed to permit free bleeding, so that the meat will have a good color. To give the carcass a better appearance, the tail is cut off, the free rear leg removed at the hock joint, and the front legs at the corresponding joint. The skin is then cut just below the hock of the suspended leg and opened to the root of the tail and along the inside of the other hind leg. The edges of the skin are separated carefully from the carcass, particular effort being made to leave all fat on the carcass as the skin is pulled down over the animal (fig. 18). This not only makes a more attractive meat product but facilitates drying the skin and prevents "fat burns" on the pelt in drying. When the skin is left entire it is known as case-skinned. Even small cuts lessen the value of the skins.

Particular care should be taken in dressing rabbits not to get hairs on the carcass. They are difficult to remove and if left give it an unattractive appearance. After the pelt has been removed the carcass should be rinsed in cold water. This facilitates removal of hair and blood, and also cleanses the carcass. It is not a good practice to leave the carcass in water more than 15 minutes. Prolonged soaking causes it to absorb water, and the resulting presence of water in the meat is considered an adulteration of the product.

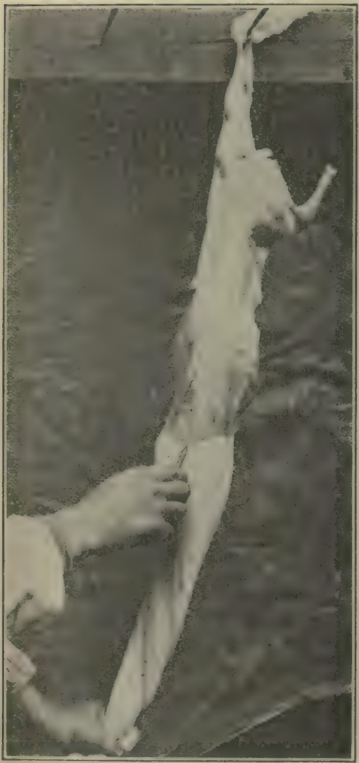

FIGURE 18.—Rabbit skins are taken off cased; that is, not split down the belly.

RABBIT MEAT

Domestic rabbit meat should not be offered for sale in the same style as wild rabbits. By offering a product that appears distinctive, producers may overcome any unfavorable impressions or prejudices that consumers have regarding rabbit meat. A neatly dressed rabbit, skinned, with the head and feet removed (fig. 19), is much more attractive in the meat market and impresses the prospective purchaser as likely to be more palatable than a rabbit partly dressed, with fur on. The heart, liver, and kidneys, especially the liver, are palatable and should not be considered as waste, for they add to the nutritional value of the product as a whole (pp. 1–2).

Wrapping the dressed carcass in cellophane will add to its general attractiveness. Rabbit meat cut into various pieces and packed neatly in a small pasteboard box with a cellophane front has a popular appeal. Special quickfreezing processes that have been developed for preserving various kinds of food have been successfully applied to rabbit meat, not only for long periods of storage but also for the immediate trade.

Directions for cooking rabbit meat can be found in Leaflet 66, Rabbit Recipes.

SKINS

Practically all rabbit skins imported from foreign countries and sold in the United States as well as those produced here eventually reach New York, the great marketing center of the raw-fur industry. There is a demand for good pelts supplied in large quantities; but raw-fur buyers do not as a rule purchase pelts in small lots, as the expense of handling them is almost as much as for a large number. Some buyers will accept a few hundred pelts at one time, but the majority prefer to purchase in quantities of 25,000 to 100,000. This has made it difficult for most American breeders, who keep only a limited number of animals, to market their skins to advantage. They have consequently been obliged to sell in small quantities at almost any price offered, or to hold skins until the necessary large shipments can be accumulated, a practice that is usually inconvenient or impracticable because of lack of proper facilities.

The possibility of developing a large, steady market for pelts depends much on the rabbit breeders' ability to furnish the types of rabbit skins required by the fur trade and to organize central collecting agencies that can accumulate pelts and sell them in large quantities. Scattered over widely separated areas, and in most instances unfamiliar with the demands of the fur trade, rabbit breeders have made little effort to sort and grade their skins or to combine their shipments so as to offer larger quantities at one time and thus realize better returns. The profits in some cases have gone to buyers or middlemen who purchase skins from the breeders at low prices and sell them in larger quantities at much higher prices.

Enormous quantities of rabbit skins are used annually by the fur trade, largely because the processes of plucking, shearing, and dyeing have been so perfected that they can produce good imitations of the more expensive skins. Another reason for the enormous consumption is the fact that rabbit skins are available as a byproduct of another and more profitable industry—production of rabbit meat. Even in domestic-rabbit skins there is a great variation in density and quality, depending upon the degree that the various breeders give to these points in their selective matings.

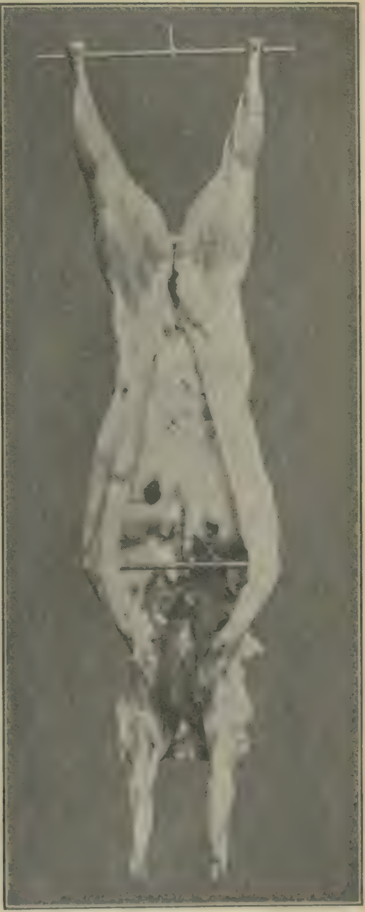
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FIGURE 19.—A dressed carcass ready for the cooler.

Fur manufacturers can use only the prime, full-furred skins; poorer grades are used by hat-felt makers. Other things being equal, white, red, and blue skins, in the order named, are in greatest demand. White skins find the most ready market with the fur trade because they can be used in their natural color or can be dyed any desired shade. For this reason white domestic rabbits have become more popular even where meat production is the primary aim.

Some rabbit skins are used in their natural colors, but this use is restricted because the rabbit breeder cannot so readily control his production as can the dyer. Even apparently well-matched raw skins become poorly matched after being dressed, and a large quantity of natural-colored skins must be available to permit proper blending of colors. Red and blue skins can be dyed many of the fashionable shades or used in their natural state undyed; but grays, browns, spotted silvers, and most others are mixed together and dyed black or some dark color. The bleaching process has been so perfected that rabbit skins of any color can now be bleached almost white at little cost and then dyed the more delicate shades. Large skins grown on the more mature rabbits during the colder months are the most suitable for the fur trade.

CURING

While still warm, skins to be cured should be placed flesh side out, the fore part over the narrow end of wire or board formers or shapers, care being taken to remove all wrinkles. Satisfactory skin shapers can be made from no. 9 galvanized wire 5 feet long. This equipment has been called a "stretcher", but the term may give an erroneous impression; it is not desirable to stretch the skins unduly, as this tends to weaken certain parts and also opens the fur. Skins should be so arranged on the shaper as to have the four legs on one side (fig. 20) and thus avoid any possible injury to the back fur, which is the most valuable. On the day after skinning, the pelts should be examined to see that the edges are drying flat and that the skin on the front legs is straightened out.

Rabbit skins should not be dried in the sun or by artificial heat, and they should be hung in such a way as to have the benefit of free circulation of air. All skins must be thoroughly dry before being packed. If they are not to be shipped for some time after being dried they should be hung in loose bundles of 50 in a cool dry place away from rats and mice. If they are kept any length of time in a warm climate or during the summer, they should be sprinkled with naphtha flakes. Salt should never be used in curing rabbit skins.

PACKING AND SHIPPING

To avoid spoilage or damage in transit, great care should be taken in packing skins for shipment. The fur should always be left inside, and so far as possible the skins should be kept in the same shape as when removed from the stretcher. Each one should be examined carefully to make sure that it is properly dried. A moist pelt or one that has patches of oily fat on it should not be packed or shipped.

Pelts that have been examined and are ready for shipment should be laid out flat, one overlapping the other, and made up into bales. Every 2 or 3 layers of skins, as they are being packed together, should be sprinkled with flaked naphthalene or paradichlorobenzene to keep out the insects that might damage the pelts in transit. When a bale has been finished it should be wrapped in paper and covered with burlap, sewed with strong cord or binder twine, and properly marked. Skins should always be well protected in this manner before being shipped.

SORTING AND GRADING

If the best prices are to be obtained, rabbit skins must be carefully sorted and graded for quality, color, and size. No mixed shipments should be offered, for if good and poor skins of different sizes and colors are mixed, the entire shipment is usually accepted at the price of the poor skins.

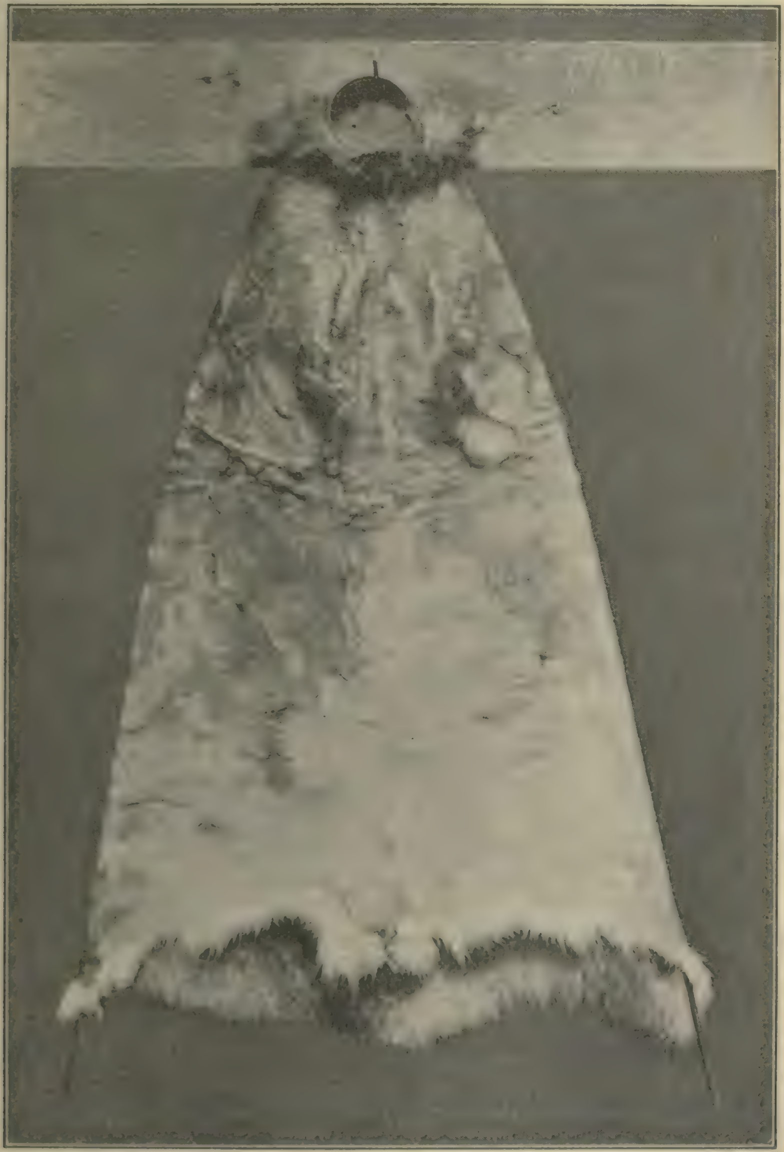

FIGURE 20.—The proper way to place a rabbit pelt on a shaper, or stretcher, all four legs on one side.

Raw-fur buyers usually grade rabbit skins as firsts, seconds, and thirds. Firsts and seconds are also divided into five classes, based on color: White, red, blue, chinchilla, and mixed. Some furriers also grade firsts and seconds as large, medium, and small. The white, red, blue, and chinchilla skins should each be packed and shipped separately, whereas skins of all other colors may be put together.

Firsts are prime pelts of large size, well shaped, and properly stretched and dried, having all the hair and underfur intact, and the skin side free from fat, flesh, dark spots, streaks, and cuts. The thicker and denser the underfur on a pelt. the more valuable it is and the better price it will bring.

Seconds are pelts that have shorter hair and less underfur than firsts, and, except in white pelts, the skin usually shows dark spots or streaks, and sometimes large black splotches. The skin of a white pelt is white, even though the fur is poor. Seconds also include pelts that are improperly stretched and dried, that have rubbed in shipment, or that show the poor spots where the skin has been pierced or the hair is short or missing.

Thirds are pelts with short hair and thin underfur and those from animals taken too young or while shedding. Pelts that are badly cut or otherwise mutilated and poorly stretched and dried also are classed as thirds. Thirds are of no value to the furrier and are used exclusively in the manufacture of felt for hats.

TRADE NAMES

The following are some of the trade names applied to rabbit and hare pelts after they have been prepared for manufacturing purposes:

Arctic Seal—seal-dyed rabbit.
Australian Seal—sheared and seal-dyed Australian rabbit.
Baltic Black Fox—black-dyed rabbit.
Baltic Brown Fox—brown-dyed hare.
Baltic Leopard—Australian rabbit dyed and marked to resemble leopard.
Baltic Lion—Australian rabbit in natural color.
Baltic Red Fox—natural red Australian rabbit.
Baltic Seal—seal-dyed rabbit.
Baltic Tiger—Australian rabbit dyed and marked to imitate tiger.
Baltic White Fox—natural white rabbit or natural white hare.
Bay Seal—seal-dyed rabbit.
Beaverette—beaver-dyed rabbit.
Belgian Beaver—beaver-dyed rabbit.
Black Hare—black-dyed hare.
Bluerette—blue-dyed rabbit.
Castorette—beaver-dyed rabbit.
Chapchillas—sheared and chinchilla-dyed white hare.
Chinchillette—chinchilla-dyed rabbit.
Coast Seal—sheared and seal-dyed rabbit.
Cony—another name for rabbits, particularly those from Europe.
Cony Leopard—rabbit dyed and marked to imitate leopard.
Cony Mole—sheared and mole-dyed rabbit.
Electric Beaver—beaver-dyed rabbit.
Electric Mole—mole-dyed rabbit.
Electric Seal—seal-dyed rabbit.
Ermiline—white rabbit.
Erminette—white rabbit.
Fox Hair—fox-dyed hare.
French Beaver—beaver-dyed rabbit.
French Chinchilla—chinchilla-dyed hare.
French Cony—sheared white rabbit.
French Leopard—hare dyed and marked to resemble leopard.
French Sable—sable-dyed rabbit.
French Seal—sheared and seal-dyed rabbit.
Imitation Ermine—white rabbit.
Lapin—sheared and dyed rabbit.
Mendoza Beaver—sheared and beaver-dyed rabbit.
Meskin Beaver—sheared and beaver-dyed rabbit.
Meskin Ermine—white rabbit.
Meskin Moline—mole-dyed rabbit.
Meskin Seal—sheared and seal-dyed rabbit.
Minkony—mink-dyed rabbit.
Molin—mole-dyed rabbit, sheared.
Moline—mole-dyed rabbit.
Muskratine—sheared and seal-dyed rabbit.
Near Seal—sheared and seal-dyed rabbit.
Northern Seal—sheared and seal-dyed rabbit.

Nutriette—rabbit sheared and dyed to imitate nutria.
Polar Seal—seal-dyed rabbit.
Red River Seal—seal-dyed rabbit.
Roman Seal—seal-dyed rabbit.
Russian Leopard—rabbit dyed and marked to imitate leopard.
Sable Hair—sable-dyed hare.
Sealette—seal-dyed rabbit.
Sealine—sheared and seal-dyed Australian rabbit.
Squirrelette—squirrel-dyed rabbit.
Squirreline—squirrel-dyed rabbit.
Visonette—mink-dyed rabbit.

TANNING SKINS FOR HOME USE

Rabbit skins to be sold should not be tanned before shipment; fur buyers prefer to purchase them in the raw state. If intended for home use, however, they may be tanned by the methods herein described, but it should not be expected that they will compare favorably in appearance and pliability with the product of a tannery or factory operated by experienced workmen and equipped with modern machinery.

In tanning, the first step is to get the skin thoroughly softened, clean, and free from flesh and grease. If cased, or whole, the skin should be split down the middle of the belly and then soaked in several changes of clean, cool water. When it becomes soft, it should be laid over a pole or board and work begun over the skin side with a coarse file or dull knife, breaking up and removing the adhering tissue, flesh, and fat, and at the same time working the grease and oil out of the skin. It is useless to start tanning until all the tissue, fat, and grease have been removed and the skin has been made uniformly soft and pliable.

The thickness and condition of the pelt determine the length of time a skin must be soaked, some skins requiring 2 or 3 hours and others longer. A skin should be soaked until it is soft, but it should not remain wet longer than necessary, as the hair may start to slip. When the skin has been thus treated and is somewhat softened, it should be worked in lukewarm water containing 1 ounce of soda or borax to the gallon. Soap added to the water is also helpful in cutting the grease and softening and cleansing the skin. After the skin has been rinsed thoroughly in lukewarm water, the water should be squeezed out, but the pelt should not be wrung. Finally, the skin should be worked in gasoline, which should remove the last particles of dirt and grease. It is then ready for tanning.

There are several methods of tanning rabbit skins. For a comprehensive treatment of tanning, the reader should consult Farmers' Bulletin 1334, Home Tanning of Leather and Small Fur Skins. Directions for using two of the more successful methods, known as the salt-acid and the salt-alum processes, are here given.

SALT-ACID PROCESS

The salt-acid formula calls for a solution made up of 1 pound of common salt and one-half ounce of concentrated sulphuric acid to each gallon of water. Dissolve the salt in the water and carefully pour in the acid while stirring. This tanning liquor should be made and used in glass or earthen jars or wooden vessels; never in metal containers of any kind. When pouring in the acid, do not inhale the fumes given off. Be careful also not to get any of the strong acid on the skin or clothing. As soon as the salt-acid solution has cooled, it is ready for use.

Put the cleaned, softened skin in the solution so that it is entirely covered. After 1 to 3 days, during which it has been stirred frequently, remove it and rinse in clean, cool water. The skin should then be worked for about 10 minutes in a solution of 1 ounce of borax to 1 gallon of water. Rinse again in clean water and squeeze (but do not wring) as dry as possible. Work the skin a few minutes in the hands by rubbing and pulling, then tack it out flat, flesh side up, and apply a thin coating of grease or oil and let it dry. Fresh butter, neatsfoot oil, or olive oil are good for this purpose.

When the pelt is nearly dry but still damp, begin to work it with the hands, stretching it in all directions and working the flesh side over the edge of a board and pulling it back and forth as if shining shoes with a cloth. If the skin is rough it may be smoothed by working it over a sandpaper block, which also helps to make it soft and pliable. Much of the success in producing a soft, pliable skin depends upon this repeated working, which must be done while the skin is drying out and not after it is dry.

If the skin is not soft enough when dry it should be dampened and worked again as before. If still greasy it may be given a hasty bath in gasoline. A final cleaning, accomplished by working the skin in warm, dry, hardwood sawdust, is beneficial and will add to the luster of the fur.

SALT-ALUM PROCESS

The salt-alum formula calls for 1 pound of ammonia alum (ammonium aluminium sulphate) or potash alum (potassium aluminium sulphate) dissolved in 1 gallon of water; and 4 ounces of washing soda (crystallized sodium carbonate) and 8 ounces of common salt dissolved together in one-half gallon of water. Pour the soda-salt solution slowly into the alum solution while stirring vigorously. Mix the combined solution, as used, with sufficient flour to make a thin paste, first mixing the flour with a little water to prevent lumps.

The skin, cleaned and softened as previously described, should be tacked out smoothly, flesh side up, on a board and then coated about an eighth of an inch thick with the tanning paste and protected with paper or sacking laid so that it does not come in close contact with the paste. The next day scrape off most of the paste and give another coating. At intervals of a day repeat this application 2 or 3 times, depending upon the thickness of the skin. Only thick skins from mature bucks will need as many as three applications. Leave the last coating on for 3 or 4 days. Finally scrape off the paste and work the skin in borax water, and rinse, squeeze, and then stretch and work it over a board in the manner described in connection with the salt-acid process.

The salt-alum process is widely used and is considered slightly better than the salt-acid tannage, although alum-tanned skins often come out stiff and hard and require much working to make them soft and pliable.

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U. S. DEPARTMENT OF
AGRICULTURE
FARMERS' BULLETIN No. 1731

ALFALFA VARIETIES IN THE UNITED STATES

THE COMMERCIAL ALFALFAS of the United States may be divided into four somewhat distinct groups, each containing strains or varieties that vary considerably within themselves: (1) The common alfalfa group, (2) the Turkistan group, (3) the variegated group, and (4) the nonhardy group.

In many parts of the United States tests have been going on for some years with alfalfa from various sources, for the purpose of determining the variety or strain that can be most profitably grown in a specific locality or under certain conditions.

As a result of these tests it is now possible to designate with considerable definiteness the part of the country where each of the various commercial strains or varieties may be expected to give the most satisfactory results.

The purchaser of seed is aided materially in obtaining the kind desired by the registration and certification service in many States; the United States Verification Service; and the staining requirements of imported seed.

This bulletin is a revision of and supersedes Farmers' Bulletin 1467, Commercial Varieties of Alfalfa.

Washington, D.C. Issued September 1934

ALFALFA VARIETIES IN THE UNITED STATES[1]

By H. L. **Westover**, *senior agronomist, Division of Forage Crops and Diseases, Bureau of Plant Industry*

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VARIETIES AND STRAINS OF ALFALFA

PRIOR TO 1898 there was no commercial recognition of alfalfa varieties in the United States whether of foreign or domestic origin, but as attempts to grow the crop spread to areas where conditions were less favorable, differences in behavior became apparent. This finally resulted in the recognition and adoption of several fairly distinct commercial varieties and strains that show great diversity in their relations to climate and latitude. Some give the best results in the North, where the winters are cold and the days are long during the growing season, while others do better in the extreme South, where the winters are mild and the days during the summer are shorter than in the Northern States.

The commercial alfalfas of the United States may be divided into four somewhat distinct groups, each containing strains[2] or varieties that vary considerably within themselves. These groups may be briefly described as follows:

The common group includes the ordinary purple-flowered, smooth alfalfa, of which there are numerous regional strains that have developed naturally in the western part of the United States and in foreign countries (fig. 1).

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[1] This bulletin is devoted mainly to a discussion of the varieties and strains of alfalfa that are of commercial importance in the United States. A few varieties that are not grown commercially but that are of interest because of resistance to cold or disease or because of peculiar adaptation have also been included. No attempt has been made to discuss many other alfalfas that have been grown experimentally from time to time.

[2] In this bulletin the word "strain" is applied to alfalfas that are only slightly different from those that are typical of the ordinary purple-flowered alfalfa and also occasionally to alfalfas that belong to other groups where they are considered with reference to these groups. The alfalfas of the common group that have developed in various regions are called "regional strains," since they do not possess sufficiently distinct characteristics to be considered as varieties.

The Turkistan group includes alfalfas that originated in Turkistan. They are similar in flower color to the common alfalfas, but the growth is generally somewhat shorter and more spreading. No commercial distinction is made between the various strains as imported from Turkistan, but in the United States the names Hardistan and Kaw are given to strains of Turkistan alfalfa, seed of which is being increased in this country.

The variegated group includes alfalfas that have originated from crosses between common alfalfa (*Medicago sativa*) and the yellow-flowered species (*M. falcata*). Grimm, Canadian Variegated, Cossack, Baltic, Ladak, and Hardigan are the best known examples of this group.

FIGURE 1.—A good crop of common alfalfa in the Yakima Valley, Wash.

The nonhardy group includes rather distinct varieties that are in general very erect in habit of growth, recover quickly after cutting, have a long growing period, and are very susceptible to low temperatures. The Peruvian and Arabian varieties are members of this group.

THE COMMON-ALFALFA GROUP

Comparatively little is known regarding the origin of common alfalfa, though there is reason to believe that it developed in western Asia and was one of the first plants to be cultivated solely for forage. The stock from which most of the common alfalfa of our Western States has been produced was brought from Spain to Chile and, after having been grown there for many years, was introduced in California about 1850. In most lots of common alfalfa there are plants that grow more quickly than others after being cut and that have a tendency to produce larger yields. These plants are favored by a mild climate and for convenience are referred to as the "southern or nonhardy type." The plants that recover more slowly after being cut and that become dormant earlier in the fall are more cold-resistant and are referred to as the "northern or hardy type." These various types furnish a basis for regional strains which, as they are at present defined, are produced when common alfalfa is grown for several seed generations in definite localities where eliminating conditions of one kind or another normally prevail. None of the common alfalfas tested thus far has shown any appreciable resistance to bacterial wilt.

DOMESTIC STRAINS

The various strains of common alfalfa produced in the United States are usually distinguished by the name of the State, as Kansas or Montana Common, or else by some term descriptive of the condition under which the seed is produced, such as "dry-land", "irrigated", and "nonirrigated" alfalfa. The environment under which alfalfa is grown undoubtedly has an important influence on its characteristics, but just how many seed generations are required to bring about a distinct change doubtless varies with the eliminating climatic conditions and cannot be estimated accurately.

The so-called "regional strains" that have developed in the Dakotas and Montana have a tendency to recover more slowly after being cut than those produced farther south and, being more cold-resistant, are preferable where winter-killing occurs rather frequently. Such strains are generally less productive at the lower latitudes than the more southern strains. The strains produced in the Southwest, often called Chilean alfalfa, recover rapidly after being cut but are very susceptible to cold and are likely to suffer serious winter injury except in the most Southern States. Common alfalfas produced in Kansas and Oklahoma are intermediate between the northern and southern types as regards cold resistance and rapidity of recovery after being cut. These strains are recommended for sections having a latitude similar to that in which the seed was produced and where winter-killing normally is not a serious factor.

The common alfalfas produced in the intermountain region vary somewhat in winter hardiness. In general they have given fairly satisfactory results where Kansas Common succeeds, though seemingly in general slightly less cold resistant. Tests conducted by the United States Department of Agriculture have not so far shown any material advantage of dry-land or nonirrigated alfalfa over seed produced under irrigation.

ARGENTINE ALFALFA

During the fiscal years 1920 to 1925, inclusive, the average annual importation of seed from Argentina amounted to about 4,000,000 pounds and created much interest in the suitability of Argentine seed for various parts of the United States. Practically all the Argentine alfalfa belongs to the common group, though several more or less distinct strains have developed as a result of having been grown under widely varying conditions of climate and latitude. Most of the seed that reaches the United States is produced south of Buenos Aires, where the climatic conditions are much less severe than those at a similar latitude in this country and therefore not conducive to the development of a hardy strain. The tests thus far conducted in the United States indicate that some strains of Argentine alfalfa are less hardy and that the hardiest strains are no hardier than our Kansas Common. For this reason Argentine alfalfa cannot be sown with safety any farther north than Kansas alfalfa is known to succeed. In the southern part of the United States some strains of Argentine alfalfa compare favorably with the domestic strains of common alfalfa.

Under the Federal Seed Act amendment, approved April 26, 1926, 10 percent of the seed of Argentine alfalfa must be stained orange-red before it is permitted entry, indicating that it is of agricultural value only in limited areas.

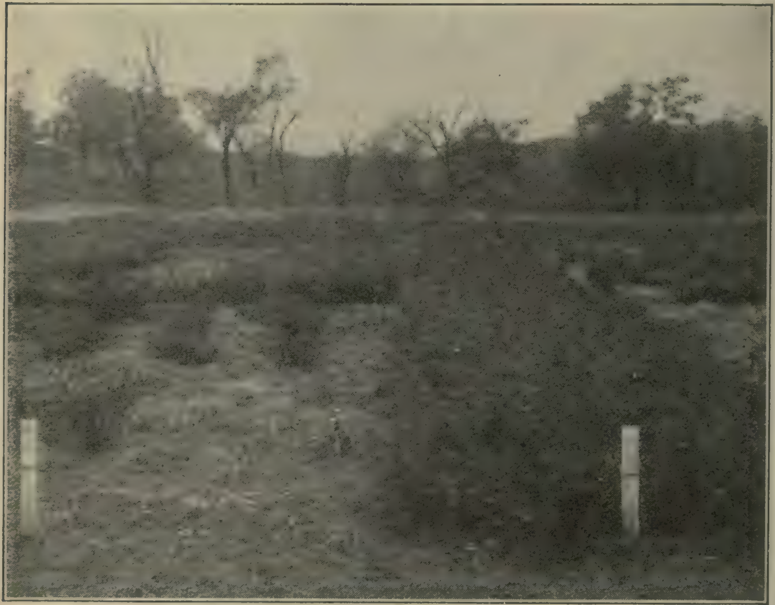

FIGURE 2.—Winter-killing in South African alfalfa (left) as compared with Canadian Variegated (right). (Courtesy Iowa Agricultural Experiment Station.)

SOUTH AFRICAN ALFALFA

During the fiscal years 1920 to 1925, enough alfalfa seed was imported from South Africa to stimulate interest in its suitability for the United States. Most lots of South African seed that have been tested have proved to be somewhat less cold-resistant than Kansas Common (fig. 2). Even where the South African alfalfa survives the winter satisfactorily it has shown no advantage over the adapted strains of domestic alfalfa.

Under the Federal Seed Act amendment, 10 percent of the South African alfalfa seed must be stained red before it is permitted entry, indicating that it is not adapted to general agricultural use in the United States.

PROVENCE ALFALFA

Provence is the name that is applied to a strain of alfalfa grown in southeastern France. It differs so slightly from the common regional strain produced in Kansas that one can scarcely be distinguished from the other. There are, however, a few differences of some importance. Provence begins growth earlier in the spring and continues to grow later in the fall in the southern part of the United States than does the strain from Kansas. It also makes somewhat quicker growth after being cut. However, it is not quite so hardy and cannot be recommended generally north of the central part of the United States.

Under the Federal Seed Act amendment, 1 percent of the alfalfa seed produced in France must be stained green before it is permitted entry.

TURKISTAN GROUP

Alfalfas of the Turkistan group include Turkistan, Hardistan, and Kaw, all of Turkistan origin either directly or indirectly. They are characterized by slow recovery after being cut, early fall dormancy, susceptibility to leaf diseases, resistance to cold and bacterial wilt, and low seed yields.

TURKISTAN

Turkistan alfalfa was first introduced into the United States through the efforts of the United States Department of Agriculture in 1898. The superior cold resistance of the early importations resulted in a demand for Turkistan seed for sowing in the cold, dry regions of the northern Great Plains. During the years 1908 to 1915 and 1920 to 1928, considerable seed was received through commercial channels, but since 1928 very little seed has been imported from Turkistan. Unfortunately, much of the seed imported was sown in the East, where it gave very unsatisfactory results, and various means were employed to warn growers against the use of Turkistan seed, particularly in the East and South. Recently, however, interest in Turkistan alfalfa has revived, mainly as a result of its resistance to bacterial wilt, a disease responsible for serious losses especially in some of the best alfalfa-growing districts of the Middle West and far West.

As compared with the commercial strains of common alfalfa grown in this country, Turkistan alfalfas are usually characterized by purple flowers; lower and somewhat more spreading growth; smaller and slightly more hairy leaves; and fine stems, but it is almost impossible even for a trained botanist to distinguish between individual plants of Turkistan alfalfa and those of the common American strains. In comparative tests Turkistan alfalfa has produced relatively low yields of seed.

Comprehensive tests have shown considerable variation in the cold and wilt resistance of Turkistan alfalfas, but fortunately seed from the main producing districts in that country has shown a rather high degree of resistance to both. In the absence of bacterial wilt some of our domestic alfalfas have been consistently more productive than Turkistan alfalfa. Even where wilt occurs, many alfalfas though susceptible to the disease usually give better yields for 2 or 3 years, but where stands are to remain longer Turkistan alfalfa will yield more in the later years. In parts of Utah and possibly elsewhere Turkistan has seemed to be more susceptible to bacterial stem blight than other alfalfas.

Experiments indicate that where bacterial wilt is destructive Turkistan alfalfa can be used to advantage in the States lying west of the Mississippi River and from Kansas northward. In certain parts of Utah the value of Turkistan alfalfa where wilt occurs is apparently limited by its susceptibility to bacterial stem blight. It has not given good results in the East, partly because of its susceptibility to leaf diseases, and partly because of its tendency to become dormant early in the fall, thus permitting weeds to invade the field and gradually crowd out the alfalfa. Both of these characteristics contribute to the short survival of Turkistan fields under humid conditions. Because of its low productivity in the Southern States, Turkistan alfalfa has not shown any promise even where bacterial wilt is prevalent.

Alfalfa seed produced in Turkistan can usually be identified by the presence of seed of Russian knapweed (*Centaurea picris*), which it almost invariably contains. This seed is considerably larger than alfalfa seed, of an oblong shape, and of an ivory-whitish color. Russian knapweed has become established in certain parts of the West, where it is regarded as a dangerous pest.

Under the Federal Seed Act amendment, 10 percent of the Turkistan alfalfa seed must be stained purple-red before it is permitted entry, indicating that it is of agricultural value in limited areas where bacterial wilt is prevalent.

HARDISTAN

Hardistan is the name given by the Nebraska Agricultural Experiment Station to a promising strain of Turkistan alfalfa grown in that State several years, seed of which was originally obtained through commercial channels. In comparative tests it has reacted very similarly to some of the commercial strains of Turkistan alfalfa as to cold and wilt resistance, susceptibility to leaf diseases, early fall dormancy, and productivity of seed and forage. Where wilt is prevalent certain domestic alfalfas are generally more productive for 2 or 3 years, but where the stands are to be maintained several years the average annual yields of Hardistan are likely to be greater, owing to the gradual thinning out of the susceptible alfalfas by the disease. Hardistan alfalfa can be used to advantage under the same conditions as Turkistan alfalfa, and like Turkistan, produces relatively low yields of seed under most conditions. The supply of commercial seed has been rather limited, but efforts are being made to increase the production, and it is anticipated that considerable seed will soon be available.

KAW

Kaw is the name given by the Kansas Agricultural Experiment Station to an alfalfa that was originally imported as Provence alfalfa from France but later found to be of Turkistan origin. Being similar in all respects to some of the better lots of commercial Turkistan alfalfa, Kaw is adapted for growing in the same parts of the United States. While the seed is not as yet commercially available, attempts are being made to increase the supply.

VARIEGATED GROUP

The variegated alfalfas have resulted from a natural cross between the purple-flowered and the yellow-flowered species. The predominant color of the flowers is similar to ordinary alfalfa, but brown, green, greenish-yellow, and smoky flowers are not uncommon, and pure yellow flowers are found occasionally. It is because of this range in flower color that the designation " variegated " is applied to the group. The various members of the group are often so similar that it is impossible to distinguish between them, but there is usually little difficulty in distinguishing between the common and variegated alfalfas by the color of the flowers and shape of the pods. As a rule, the alfalfas of this group are more resistant to cold than common alfalfas, probably because of the presence of the yellow-flowered blood in their ancestry. With the exception of Ladak, none of them has shown any appreciable resistance to bacterial wilt.

GRIMM

Grimm alfalfa is the most important member of the variegated group in the United States. It was introduced from Germany into Carver County, Minn., in 1857 by Wendelin Grimm and eventually attracted considerable attention on account of its cold resistance.

To the casual observer Grimm alfalfa differs little from the common strains, but a closer examination will reveal a greater diversity of forms. While the flowers are mainly similar to common alfalfa in color, the presence of variegated flowers characteristic of the group indicates definitely that the Grimm alfalfa is the result of a cross between the common and the yellow-flowered species. Variegated flowers are usually more in evidence in semiarid than in humid districts.

The hardiness of the Grimm alfalfa is probably due in part to the presence of yellow-flowered alfalfa in its ancestry and in part to the process of natural selection that took place under the severe climatic conditions to which it was subjected for many years in Minnesota. On account of its superior hardiness the variety is particularly recommended for all the Northern States where winter-killing is a serious factor (figs. 3 and 4). In the southern half of the United States it is less productive than some of the less hardy and more rapid growing alfalfas.

In ability to produce seed Grimm alfalfa is at least the equal of common alfalfa.

COSSACK

Cossack alfalfa was introduced into this country from Russia through the efforts of the United States Department of Agriculture in 1907. It is an earlier generation hybrid between the common and yellow-flowered alfalfa than Grimm, and for this reason the flowers show a higher percentage of variegation, the yellow and white flowers being more abundant. In certain tests Cossack has yielded somewhat more than Grimm and other variegated alfalfas, but on the whole it has not shown evidence of being appreciably superior for most conditions. It is adapted for growing under practically the same conditions as Grimm alfalfa.

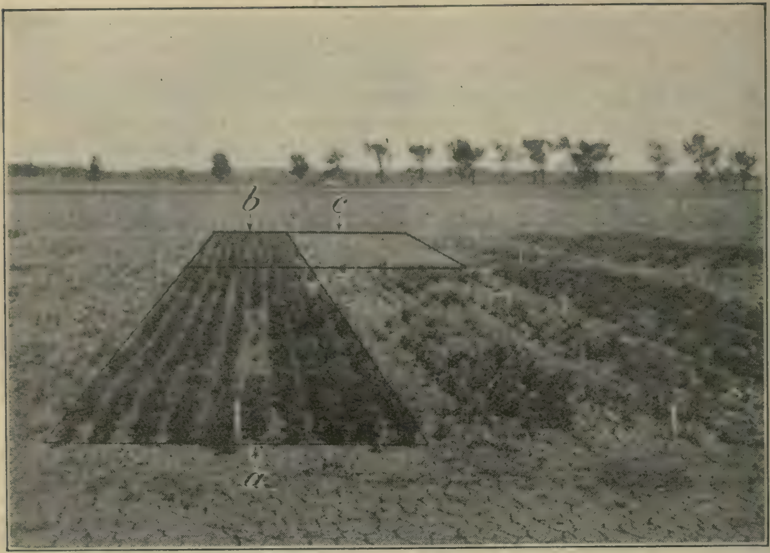

FIGURE 3.—Effect of cold on alfalfa varieties at Ames, Iowa: *a*, Grimm; *b*, Canadian Variegated; *c*, Hairy Peruvian. (Courtesy Iowa Agricultural Experiment Station.)

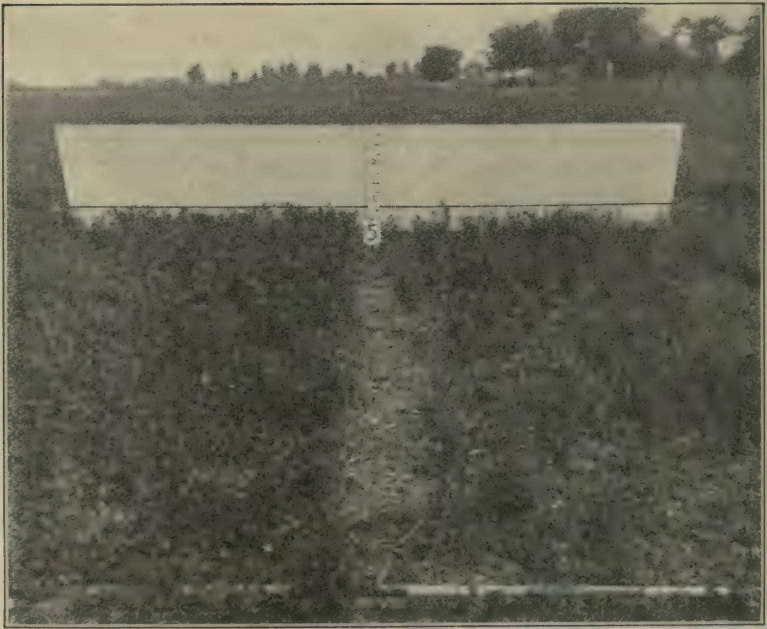

FIGURE 4.—Winter-killing in Utah Common alfalfa (right) as compared with Grimm alfalfa (left). (Courtesy Iowa Agricultural Experiment Station.)

CANADIAN VARIEGATED

Canadian Variegated, or Ontario Variegated, is the name given to an alfalfa of hybrid origin grown in eastern Canada for many years. It is very similar to the Grimm variety as to flower color and general habit of growth. In fact, these two varieties are so much alike that it is seldom possible to distinguish one from the other. Canadian Variegated also compares very favorably with Grimm in yield of seed and hay, but, like it, does not usually yield so much as common alfalfa where the latter survives the winter without injury. It has proved more cold-resistant than common alfalfa and is adapted to about the same general region as Grimm (figs. 2 and 3). In New England and other States having approximately the same latitude, its superior hardiness as compared with ordinary alfalfa has been pretty well demonstrated. In tests conducted in the northern Great Plains it has not usually survived the winters quite so well as the Grimm.

Under the Federal Seed Act amendment, 1 percent of the seed must be stained iridescent violet before it is permitted entry.

LADAK

In 1910 a small quantity of alfalfa seed was obtained from Ladak, northern India, through the efforts of the United States Department of Agriculture, and a little later several other small packets were obtained from the same source. This alfalfa appeared very promising in the preliminary tests in the northern Great Plains, where it suffered less winter injury and generally was more productive than most other alfalfas. When it seemed likely to become of commercial importance the name Ladak was assigned to it.

No other alfalfa grown commercially in the United States shows such a wide variegation in growth habits of individual plants, some being very desirable and others undesirable, thus offering an excellent source of material for selection. Plants obtained from the original seedings were predominantly yellow-flowered, but hybridization in subsequent generations has resulted in a gradual increase in the proportion of purple flowers. The variety, however, still shows more variegation with a greater percentage of yellow flowers than any other alfalfa in the group.

In the region where Ladak alfalfa is adapted one of its outstanding characteristics is its ability to make an exceptionally heavy first crop. As it exceeds all other varieties in this respect, it is especially valuable where only one good cutting is normally obtained. It recovers slowly after being cut, and as a result the second and third crops of other varieties often exceed in yield those obtained from Ladak. Because of the heavy first cutting, however, the total seasonal yield of Ladak is often in excess of that of other varieties.

Like Turkistan, Ladak alfalfa has a tendency to become dormant early in the fall. Being relatively free from leaf diseases, it retains its leaves remarkably well, and thus yields a high quality of hay. It has also shown considerable resistance to bacterial wilt, though not equal to that of the alfalfas of the Turkistan group in this respect.

In many tests Ladak alfalfa has proved superior to all others for the cold and dry conditions found in the northern Great Plains, and it has also given good results under irrigation in the Northwest.

Even as far south as Manhattan, Kan., yields obtained from Ladak have compared very favorably with those obtained from other alfalfas. Where wilt is prevalent in this general region, Ladak has considerable advantage over other variegated and common alfalfas. East of the Mississippi River, the variety has given variable results. It has stood at or near the top in yield in a few tests conducted as far east as Ohio. Farther east Ladak alfalfa, like Turkistan, has not appeared promising, owing apparently in part to its slow recovery after being cut and to its tendency to become dormant early in the fall, giving an opportunity for weeds to invade a field, thus gradually crowding out the alfalfa. It is not suited to the southern half of the United States.

There is at present a considerable acreage of Ladak alfalfa, principally in Montana and Oregon, and during favorable seasons considerable seed is produced though the price is still relatively high.

BALTIC

There is no authentic record of the introduction of Baltic alfalfa into this country, although there is no doubt that the original stock came from Europe. The name Baltic was first applied to it in 1906, for the reason that it had been grown for about 10 years near Baltic, S.Dak., and not, as has been supposed, in the Baltic Sea region of Europe.

This alfalfa differs slightly from Grimm alfalfa in some minor details, but the two are so similar that it is seldom possible to distinguish one from the other, and the description as given for the Grimm variety applies equally well to Baltic. In some tests Baltic alfalfa has slightly exceeded Grimm and in others the reverse has been true, but in general the two varieties may be considered of about equal value.

Baltic alfalfa has unquestionably been developed in much the same way as Grimm and therefore owes its hardiness to the same causes, the presence of the yellow-flowered alfalfa in its ancestry and the natural elimination of the less hardy plants as a result of having been grown under severe climatic conditions.

This variety is best suited for sections where the ordinary alfalfas suffer considerable winter-killing. These sections include practically the same territory as that to which Grimm is best adapted.

HARDIGAN

Hardigan alfalfa is a selection from Baltic made at the Michigan Agricultural College for its high seed production and as a desirable forage type. In general growth habits it is similar to Grimm and other variegated alfalfas. The flowers, however, are largely purple, very little variegation being in evidence. Hardigan alfalfa blossoms more freely and, where conditions are conducive to seed setting, produces larger yields of seed than almost any other alfalfa. In many parts of the East, however, it has not produced profitable yields of seed in most seasons, indicating that the problem of seed production under humid conditions cannot be solved by its use. In cold resistance and productivity it is similar to Grimm and Baltic alfalfa and is, therefore, adapted to about the same region as other variegated alfalfas, namely, the Northern States where winter-killing is likely to be serious.

SAND LUCERN

Sand lucern, a member of the variegated group, is no longer grown commercially as such in the United States. Numerous lots of seed have been tested in the past, and considerable variation has been noted in cold resistance and growth habits. It is believed that the Grimm, Baltic, and Canadian Variegated alfalfas are the result of natural selection from the sand lucern of Europe.

NONHARDY GROUP

There are certain alfalfas distinct from the regional strains of common alfalfa that have been developed in the southern part of this country. These alfalfas are especially characterized by long periods of growth, by ability to make better growth under short days than the hardier northern strains, and by quick recovery after being cut. Because they are so much more seriously affected by low temperatures than the other commercial varieties or strains, for lack of a better group designation they have been classed as nonhardy alfalfas. Included in the group are such alfalfas as Peruvian, Arabian, and India, though only the Peruvian alfalfas have attained any degree of commercial importance in the United States. All nonhardy alfalfas tested for wilt resistance have proved highly susceptible.

PERUVIAN

Peruvian alfafa was first introduced into the United States through the efforts of the United States Department of Agriculture in 1899. Two distinct types have been noted in alfalfas from Peru, differing in several respects but most noticeably in the abundance of hairs on the leaves and stems. These two alfalfas are distinguished by the names "smooth Peruvian" and "hairy Peruvian." At one time there was a considerable acreage of smooth Peruvian in Arizona, but it has gradually decreased in importance. At present only the hairy Peruvian is receiving much attention, and even it seems to be gradually declining in popularity.

As compared with common alfalfa, the Peruvians are more upright, less branched, and have fewer and somewhat coarser stems, though in thick stands this difference is not marked. The most striking characteristic of hairy Peruvian is the pubescence or hairs on the whole plant, giving the foliage a grayish appearance.

The Peruvian alfalfas are characterized by their rapid growth, quick recovery after being cut, and in sections having a mild climate, by their ability to grow in cold weather and short days after the growth of ordinary alfalfa has ceased. Under such conditions they begin growth earlier in the spring and continue to grow later in the fall than most other commercial varieties, thus lengthening the growing period and therefore giving more cuttings during the season. Hairy Peruvian exhibits this characteristic to a somewhat greater degree than smooth Peruvian.

Lack of hardiness will always confine Peruvian alfalfa to the southern and southwestern portions of the United States, where the winter temperatures are comparatively mild (fig. 3). It cannot be grown to advantage in regions where the temperature falls below 10° F., and efforts to extend its culture into the Central and Northern States are unwarranted and sure to result disadvantageously. Peruvian alfalfa is not drought-resistant and therefore is not to be recommended for dry-farming sections.

ARABIAN

Arabian alfalfa was introduced into the United States in 1902 and first attracted attention because of its rapid growth. It has a tendency to be short-lived but because of its rapid growth might be of value in short rotations. At present, however, there is no known source from which seed can be obtained in commercial quantities.

YELLOW-FLOWERED GROUP

The yellow-flowered alfalfas are of no commercial importance since very little seed is available, but, being very cold-resistant, they are of interest for hydridizing with purple-flowered alfalfa in an effort to produce a hardier variety. They exhibit a wide range in growth habits, some being prostrate and others upright. Even the upright types ordinarily produce only one satisfactory cutting, and the yields are therefore relatively low. Furthermore, seed is produced in small quantities and shatters badly. At one time there was considerable interest in two yellow-flowered alfalfas, Orenberg and Semipalatinsk, but no seed is commercially available at present.

VARIETIES FOR VARIOUS SECTIONS

In many parts of the United States tests have been going on for some years with alfalfa from various sources, the objective being to determine the variety or strain that can be most profitably grown in a specific locality or under certain conditions. As a result of these tests it is now possible to designate with considerable definiteness the part of the country where each of the various commercial strains or varieties may be expected to give the most satisfactory results.

The common alfalfas vary considerably in hardiness, depending mainly upon the conditions under which a particular strain has developed. Their range of adaptation covers much of the United States, the northern and more cold-resistant strains being best suited for growing in the Northern States and the southern nonhardy strains for the Southern States. In general, common alfalfa may be expected to give fairly satisfactory results in the latitude in which the seed has been grown for several seed generations. Even the hardiest strains of common alfalfa are not dependable where the winters are particularly severe. The hardier variegated alfalfas are much to be preferred under such conditions.

The Grimm, Cossack, Baltic, Canadian Variegated, and Hardigan varieties are more cold-resistant than any of the common alfalfas and may be used to advantage from about the fortieth parallel northward and at higher altitudes farther south. There are many areas within this region where soil and climatic conditions are particularly favorable to the growth of alfalfa and where some of the common alfalfas may be used to advantage, especially in short rotations, the seed being somewhat cheaper. Even under these more favorable conditions, however, the variegated alfalfas have generally been somewhat more productive in the northern half of the United States. They have usually been inferior to the common alfalfas in the South.

Ladak alfalfa is adapted to the part of the country lying west of the Mississippi River and from Kansas northward, being especially valuable for the cold, dry conditions in the northern Great Plains and for areas where bacterial wilt is prevalent. In limited tests Ladak has succeeded fairly well in Northern States as far east as Ohio, but from this point eastward it has not compared very favorably with other variegated alfalfas. It is not adapted to the southern half of the United States.

Turkistan, Hardistan, and Kaw alfalfas are recommended for wilt-infested soils west of the Mississippi and from Kansas northward. They have not generally given good results in the Eastern or Southern States.

Peruvian alfalfa, like strains of common alfalfa grown in the Southwest, can be used to advantage only where the winters are mild. The section to which this alfalfa is adapted includes the greater part of California, except the mountainous portions, southern Arizona, southern New Mexico, southern Texas, and the coastal region of the South Atlantic and Gulf States.

SAFEGUARDS IN PURCHASING SEED

At one time, farmers encountered difficulty in obtaining seed of the kind of alfalfa desired owing to misrepresentation, intentional or otherwise, and serious losses were incurred from sowing unadapted seed. This situation, however, has been largely remedied, and by observing the registration and certification requirements in many States, the United States Verification Service requirements, and the seed-staining regulations as applied to imported seed the purchaser may be reasonably sure of the variety and origin of the seed.

Several States register and certify seed as to variety, each package bearing a tag to this effect. Varieties so registered and certified include Grimm, Cossack, Baltic, Ladak, Hardigan, and, in some States, seed from fields of common alfalfa of long standing.

The United States Verification Service verifies the origin or place where the seed was grown without regard to the variety, quality, purity, or germination. Each package of such seed bears the United States Verification tag.

An amendment to the Federal Seed Act [3] approved April 26, 1926, requires that alfalfa seed from foreign countries be stained before it is permitted entry into the United States. In accordance with the provisions of this amendment and of regulations issued thereunder, alfalfa seed is prohibited entry unless complying with the following requirements as to staining.

In the case of alfalfa seed from any foreign country, 1 percent of the seed in each container is to be colored green with the following exceptions:

Seed from Turkistan, 10 percent purple-red.
Seed from Africa, 10 percent red.
Seed from South America, 10 percent orange-red.
Seed from Canada, 1 percent iridescent violet.
Seed of unknown origin, 10 percent red.

In some cases seed represented to be Grimm alfalfa is offered as "Affidavit Grimm." Tests conducted by the United States Department of Agriculture indicate that such seed cannot always be relied upon as being true to name, since some of the lots have been found to consist largely or in part of common alfalfa.

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[3] For the complete text of the regulations, see Service and Regulatory Announcements No. 9, Joint Resolutions * * * under the Federal Seed Act * * *, of the Bureau of Plant Industry, issued July 1926, and notices nos. 4 and 5, issued under sec. 5 of the Federal Seed Act, Apr. 2, 1927, and Mar. 27, 1933, respectively.

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U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1732

GROWING BARLEY for MALT AND FEED

BARLEY IS GROWN for both malt and feed. It is the purpose of this bulletin to make available to the farmer such information as may enable him to decide which variety to grow and whether or not to exercise the care necessary to obtain grain that meets the maltster's requirements.

The maltsters of the Central and Eastern States desire such barleys as Oderbrucker, Manchuria, Wisconsin Pedigree 38, Velvet, etc. They wish these barleys to be well grown, plump, mellow, carefully threshed, and free from disease and weather damage. Certain sections discussed in the bulletin are particularly adapted to the growing of these varieties and to the production of the quality desired. In the Western States varieties with larger kernels, such as Atlas, are grown. Barley of good malting quality is rarely produced except in sections where it is the major crop.

The greater part of the barley produced is certain to be fed. Barley is a very useful grain feed, and the yield per acre is high in the Northern and Western States. Many farmers should grow barley for consumption on the farm.

Washington, D.C. Issued May 1934

GROWING BARLEY FOR MALT AND FEED

By H. V. Harlan, *principal agronomist, Division of Cereal Crops and Diseases, Bureau of Plant Industry*

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RECENT TRENDS AND PRESENT PROBLEMS IN BARLEY GROWING

BARLEY GROWS WELL in a cool, humid climate. It will stand more heat under semiarid conditions than under humid conditions. When grown in warmer climates, it is often winter-sown. The most favorable growing conditions are found in the Northern and Western States, where it produces a high yield of grain per acre. Gradually farmers in these States have come to realize the high value of the barley crop, and there has been a slow expansion of the acreage. The average yearly production now is much greater than before the prohibition era. Any increase between 1918 and 1933 was obviously for feed. If the present trend is continued, less than one fourth of the crop will be absorbed by the maltsters. Farmers are naturally attracted by the premium for malting barley. It is a new source of revenue and a profitable one. Three fourths of the average crop, however, will not receive a premium. In favorable years barley of good malting quality is produced over wide areas, and the price is accordingly depressed. The gains in balanced husbandry should not be sacrificed in mass attempts to produce malting barley. Only those farmers who have a reasonable chance of harvesting grain of the desired quality are justified in changing from a feed to a cash crop. The farmers most likely to profit from the new market are those located on suitable lands in barley-growing sections. In such locations varieties wanted by the buyers can be grown with little or no sacrifice of yield. The local market also is built around the malting demand, and the local grain dealer is in touch with the market and equipped to serve the grower by not allowing the better barley to lose its character through mixture in the elevator or in shipment. Facilities for preventing mixture are not available in localities where little barley is grown.

In general, feed barleys should be grown by farmers who expect to use the crop primarily as feed; by farmers in sections where little barley is grown; by farmers in sections where the malting varieties yield decidedly less than the feed varieties; and by farmers in any section where farms are of such character that good malting quality is rarely produced. The market preference for varieties is of little importance to the farmer who feeds his crop, and malting premiums are of little interest to the farmer who cannot grow malting barley.

Barley growers are at the crossroads. The growing of barley should be continued on a healthy basis free from violent shifts of acreage on account of large premiums or lack of premiums for malting barley. This can be done only by maintaining a large acreage destined for feed. The soundness and permanence of the barley acreage is dependent on the combined judgment of the individual planters.

MALTING BARLEY

NORTHERN AND EASTERN STATES

Any discussion of malting barley is complicated by the great diversity of soil and climate found in the United States. The types suited to the several regions are so different and the methods of growing and caring for the crop so various that the subject cannot be discussed from the standpoint of a single section. The country, however, can be divided into regions which will be discussed separately. The three most important divisions are shown in figure 1. As far as the American market is concerned, the most important region consists of the Northern States east of the Missouri River. Although many kinds of barley are grown in this region, the so-called "malting varieties" do well throughout the area, and an acceptable quality results where and when the soil and seasonal conditions are favorable. The malting market, however, is a critical one, and if the farmer wishes to be successful in this field he must be familiar with the requirements.

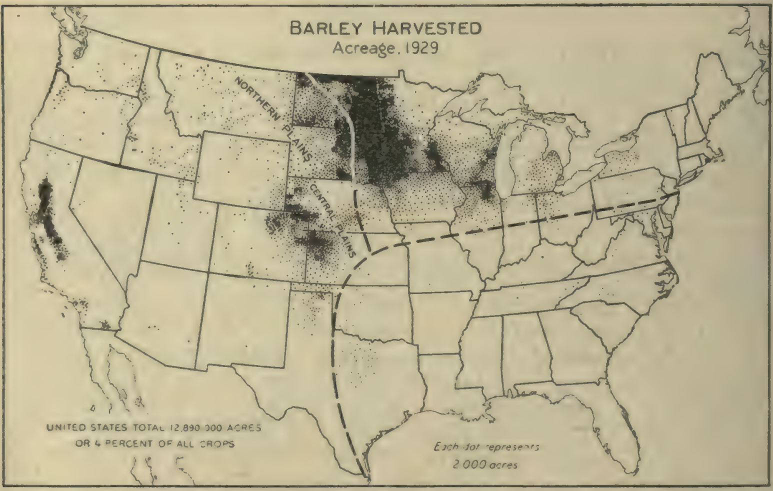

FIGURE 1.—The three general regions of barley production in the United States. The heavy broken lines divide the country into the humid-spring region (northeast), the humid-winter region (southeast), and the semiarid region (west). The dots show the acreage according to the census of 1930. Localities suitable for barley growing are indicated by the present distribution of the crop.

WHAT THE MALTSTERS WANT

The eastern maltsters and brewers want a plump, mellow, small-kerneled barley with firm hulls not easily damaged. They wish this barley to be all of the same type, sound, carefully threshed and free from weather and disease damage. In actual field culture grain is seldom produced that is free of all objectionable features. The farmer growing barley for market should not only make every reasonable effort to enhance the quality as far as it is determined by the factors under his control, but should also be sufficiently familiar with malting requirements to be able to decide whether or not his barley meets these requirements.

Federal grades for malting barley under the Grain Standards Act have been established for barley grown east of the Rocky Mountains, effective July 2, 1934. The requirements for malting barley include the following specifications:

"This subclass shall include 6-rowed barley of the class barley (class I) which meets the requirements of grades nos. 1 to 3, inclusive, which, after the removal of dockage, contains not more than 5 percent of 2-rowed and/or other types or varieties of barley of unsuitable malting type, such as Trebi and black; which contains not more than 15 percent of barley and other matter that will pass through a 20-gage metal sieve with slotted perforations 0.076 $({}^{4\,7/8}/_{64})$ of an inch wide and ¾ of an inch long; which contains not more than 5 percent of skinned and/or broken kernels; which contains not more than 4 percent of damaged barley; and shall not include bleached barley. Barley of this subclass shall contain 75 percent or more of mellow barley kernels, which kernels are not, en masse, semisteely."

Black barleys (such as Lion) are objectionable not because they differ much from Oderbrucker, but because black kernels are sometimes difficult to distinguish from heat-damaged kernels and because the maltsters do not want them and pay less for barley when they are present.

Broken kernels are objectionable in barley intended for malting purposes because the broken kernels will not malt and must be removed to be sold as feed barley. Skinned kernels are even more objectionable than broken kernels because they cannot be screened out of barley intended for malting purposes and because they do not germinate and convert properly during the malting process. Frayed ends are objectionable. In many cases such kernels are damaged. Even if no real injury exists, malt made from barley containing many frayed ends has a poor appearance and will not sell so well as malt made from barley with unbroken hulls. Only 4 percent of damaged barley of all kinds are allowed in the malting grades. Damaged barley includes blighted, moldy, heat-damaged, sprouted, and badly weather-damaged kernels. Blighted kernels, which include those affected by scab and stripe, may be very objectionable, and the limit of tolerance cannot be much greater than the amount specified in the grades.

LOCATION AND SOIL

Most of the barley that is malted is produced in a few States in the upper Mississippi Valley. In these States the best of the crop comes from a few localities. In the most-favored localities grain of malting quality is produced almost every year. Other sections produce good grain in 3 years out of 4, in half the years, or only occasionally. Small areas where high-quality barley is produced are to be found in all States from western New York to South Dakota. Such areas are well known to local farmers. Obviously the growers so favorably situated now produce and probably always will produce the greater part of the market requirements.

In the barley-growing areas some farms are better suited than others for the growing of high-quality barley. The best barley soils are well-drained loams. Barley cannot stand "wet feet." For this reason, heavy, poorly drained soils do not produce good barley in regions of frequent rains. Not only is the grain likely to be coarse, but the plants are more likely to be infected with blight and scab. On the other hand, light sandy soils are poor barley soils. Growth is not maintained at a sufficiently uniform rate, and ripening is often hastened by drought.

VARIETIES

The choice of variety is important. No variety, however, will produce malting barley in a section not suited to barley, nor can it overcome an adverse season. The fact that a variety produces grain of fine quality in western New York should not encourage a farmer in Iowa to plant it in his fields. The State experiment stations are testing all promising sorts and are the best sources of information for local use. Full information can be had on many varieties, but some of the newer ones must be grown several years before they can be accurately appraised. The type wanted is definite. Maltsters express a decided preference for barleys of the Manchuria-Oderbrucker group and smooth-awned hybrids from these parents. Large-kerneled 6-rowed varieties and 2-rowed sorts are apparently not in demand in this area. Oderbrucker, Manchuria, Odessa, and the smooth-awned hybrids, Wisconsin Pedigree 38 and Velvet, seem to be acceptable. Manchuria, which is blue or mixed blue and white, and such blue selections of Manchuria as O.A.C. 21, are disliked by some maltsters because of the blue color, which makes the determination of mellowness more difficult. The blue color in itself is entirely harmless, being merely a pigment deposited in the outer layer of the endosperm. It has nothing to do with malting quality. The smooth-awned varieties have a tendency to peel more easily than Manchuria or Oderbrucker. This is an undesirable character. It is worse in poorly grown barley than in plump, well-matured barley. When carefully threshed, the smooth-awned sorts meet the market requirements.

SEED AND SEEDING

Seed should be sound, clean, and of high germination. The use of the fanning mill is important, because it removes weed seeds and many of the diseased kernels. There is a common impression that seed of high malting quality is desirable for sowing. This is true only as far as malting quality indicates strong germination and freedom from disease. Hard, flinty, steely barley is just as desirable for seeding as is the finest malting barley of the same variety if the germination is equal.

Seeding should be early for the locality. Barley does not grow well in hot, humid weather, and there is a decided advantage in early seeding.

ROTATION

Barley of high quality is seldom produced on land that is too highly fertile. On rich lands manures are best applied to the preceding crop. The residual effect is sufficient for barley. Coarse grain and lodging are often prevented in this way. In areas where scab is serious, barley should preferably follow some other crop than corn or small grain.

HARVESTING AND STACKING

In the harvesting of malting barley the farmer must meet a number of serious problems. Sound, fully ripened grain is without question of great importance to the maltster. On the other hand, the longer the grain stays in the field, the greater the hazards from storm and moisture damage. Ripened under the best of conditions in a humid climate, the grain assumes a bright straw color.

Quality is often seriously impaired during ripening and harvesting. The crop should stand until it is fully ripe. Not only is the grain more mellow, but the proteins cause less trouble in brewing. The proteins of growing grain are very different from those in the fully matured kernel. The same is true, in a way, with the starch. If growth is arrested by drought or too early cutting, the kernels are likely to be "steely." Such grain does not malt well and brews worse. Care should be taken not to cut the crop too soon. Probably the thumb-nail test to determine maturity is as good as any. Grain is ready to cut when it has reached the point where it will retain the imprint of the thumb nail pressed against it.

Color can easily be overemphasized. In dry areas or where the crop ripens without rain or dew, perfectly matured grain may have very little of the yellow color that is characteristic of grain ripened where light rains and dews are common. A deeper color in humid districts is not a cause for a lower price, and the farmer should not sacrifice quality to secure grain that exhibits the same brightness as that found in the drier areas.

Frequent rains at harvest time often injure the quality of the grain. Any considerable number of kernels with blackened ends lowers the market value. Musty odor is a danger signal to the barley buyer, and even a small percentage of decayed kernels may remove a shipment from the malting class. Extra care must be used in shocking and stacking barley intended for the malting market. Minimum exposure to unfavorable weather is desirable.

Stacking improves the quality of barley. Something occurs during the process of going through the sweat in the stack that makes barley more mellow and increases both the vigor and percentage of germination.

THRESHING

Great care should be exercised in threshing malting barley. Skinned and broken kernels are a hazard to the maltster, and any chance of receiving a premium for the crop can be ruined in threshing. The maltster would prefer to have a few awn fragments remaining on the grain than to be confronted with threshing damage. Especial care may need to be taken with the smooth-awned varieties. Any thresher can adjust his machine to decrease threshing damage. Square teeth in the concaves instead of rounded ones result in fewer broken kernels in the final product. The elimination of end play in the cylinder is of great importance.

CENTRAL PLAINS

The area discussed as suitable for the Manchuria-Oderbrucker type of barley has been very crudely bounded. "East of the Missouri", of course, does not mean that the Missouri River marks a definite boundary. Eastern Nebraska, for instance, is as much a part of the region as southern Iowa. As one goes farther west, however, conditions gradually change. The Manchuria-Oderbrucker types do not yield so much as many others do, and they shatter badly in the drier regions.

The western types come into competition with the eastern ones in northwestern Kansas and adjacent areas. The most dependable varieties in this transition area in the past have been related to those long grown on the Pacific coast. Manchuria-Oderbrucker types also can be grown, although at some sacrifice of yield. The maltsters on the eastern markets prefer this latter type, but when of good quality the larger-kerneled Coast type is also in some demand. Under such conditions the farmer has a difficult decision to make. The correctness of this decision is dependent on many factors beyond his control. Whether he has good barley depends on the season. Whether or not there will be a profitable premium for it depends on the seasonal conditions over a wide area.

NORTHERN PLAINS

Recommendations for the dry lands of Montana and adjacent areas are equally difficult at present. The Manchuria-Oderbrucker barleys do not yield well and they shatter badly. The brewing value of Montana-grown Horn and Trebi has not been established. The quality exhibited by these varieties in other areas is little indication of what they may do here. When brewers have used barley produced in this area during 1 or 2 average years, a reasonably sound recommendation can be made. Until this information is available, none can be given.

MOUNTAIN STATES

The agriculture of the western mountain country, like that of all mountain countries, is largely confined to the many irrigated valleys, each one a problem in itself. Regardless of variety, the grain from these valleys will always be plumper, of lower nitrogen content, and more mellow than that produced in the upper Mississippi Valley. Grain of the character obtained in the upper Mississippi Valley could not be produced even if it were desired. Furthermore, in this area, barleys of the Manchuria-Oderbrucker type shed most of their kernels before harvest. The brewing problem here, then, becomes quite different from that in Milwaukee or Chicago. If the brewer uses local material, he will probably find it good and far more uniform than that of the East, but he must of necessity develop his own methods of utilization.

Volume is, of course, limited since under highly specialized irrigation farming, the percentage of land in grain is not large and much of the barley produced is needed for feed. The scarcity of feed grains in the Mountain States and the high price paid for them often makes the importation of malt economical.

Since the better barley in the Mountain States is produced under irrigation, the judicious use of water is important. Unfortunately, there are no rules by which the most favorable conditions can be obtained or maintained. No two fields or two seasons are alike. The object of irrigation is, of course, to keep the plants growing well, and the timing of the watering must depend on the judgment of the farmer. Wherever possible, the land should be so handled that there will be sufficient water in the soil to germinate the grain. Applications of water after seeding to start growth are usually disastrous. Too-rank growth at heading time is undesirable. Late irrigations are also a problem. There is danger of lodging the grain. On the other hand, failure of water before full maturity cuts heavily into the yield and lowers the quality. Barley kernels continue to grow until they dry. Any kernel that will not retain the imprint of the thumb nail is still growing. Thinly seeded nurse crops often produce high yields because irrigations are continued to save the grass. If possible, the last irrigation should be late enough to furnish moisture until the plant has ripened naturally. When malting barley is grown under irrigation, the threshing should be watched carefully. The dry kernels break easily, and most threshers in this region are inexperienced in adjusting their machines to meet these particular market requirements.

PACIFIC COAST

The conditions on the Pacific coast are peculiar to that section. Most of the market barley is raised in the interior valleys of California. The small-kerneled Manchuria-Oderbrucker barleys cannot be grown. England furnishes the market and her maltsters prefer barleys of the Coast type. Atlas is the dominant variety at present. Purity of type and freedom from threshing damage are important and are under the control of the farmer. Club Mariout is useful in late sowing and, when well grown, is used by some of the English maltsters. Its price on the English market is less than that of Atlas. The Coast type of barley was formerly produced in some quantity in eastern Oregon and Washington. There are also special areas where barleys of other types and of high quality can be grown, as in the Salinas Valley of California and the region west of the Cascades in Oregon and Washington.

SOUTHERN STATES

There are many local areas where barley can be grown that cannot be separately discussed. In the Southeastern States, for instance, bearded winter barley is grown that is quite similar to the Manchuria-Oderbrucker type. Conditions at harvest are often unfavorable, and over most of the South the growing of malting barley is not recommended.

FEED BARLEY

Feed barley is barley used as feed. It may or may not be of the varieties or qualities desired by maltsters. It may be grown solely for feed, or it may be the result of an unsuccessful attempt to grow barley acceptable to the maltsters.

Market terminology has done much to retard the expansion of the barley acreage. Grain rejected by the maltsters is called "feed barley." It usually consists of inferior grain and is only second-rate feeding material. Barley grown for feed need not be inferior grain. Indeed, in the good barley sections it is usually of relatively high quality.

In many ways it is unfortunate that feed barleys are not a crop entirely distinct from malting barleys. The value of barley for feeding must be measured by its usefulness on the farm. The return in terms of pounds of pork or gallons of milk should be the farmer's gage. The appraisal of feed barley would be much less difficult if there were no other barley market.

In the years when brewing was prohibited there was a marked increase in the barley acreage. This increase was, of course, for feed. Much of the recent shifting in barley acreage has been outside the better-known area of malting-barley production. There was a short-lived expansion into the Corn Belt. A heavy infection of scab discouraged any rapid or careless expansion in this direction. On the Great Plains there is an apparently permanent increase. This has been particularly heavy in northwestern Kansas. In western Oklahoma and adjacent areas there has been a fluctuating acreage of winter barley with an upward trend. There is also an active interest in winter barley in the Southeastern States, where the acreage for feed is increasing. Spring barley is best adapted to the Northern and Western States. Much of this area is outside the Corn Belt. A grain feed that may be substituted for corn is, of course, of great value. Barley is particularly suited to this purpose, both because of its yielding capacity and its feeding value.

On favorable soils barley yields more pounds per acre than any other small grain. It fits in well with the systems of agriculture practiced in most of the areas where the crop is adapted. It can be fed to all classes of livestock and is constantly increasing in popularity with dairy farmers. It is almost the equal of corn as a feed. As in the case of corn, it is especially prized as a feed for hogs because it produces firm pork. The value of clean and sound barley for feeding hogs depends largely upon its weight per bushel. Barley weighing 48 pounds per bushel has almost the same value as corn. If it weighs only 44 pounds per bushel, experiments indicate that it is worth about 10 percent less per bushel for hog feeding. This is due to its higher fiber content, greater bulkiness and, therefore, lower nutritive value. For other classes of livestock the higher fiber content is not such an important factor. In fattening cattle, scabby barley, which has a considerably lighter weight per bushel than sound barley, has practically the same value pound for pound as sound barley. Ordinarily, hogs will not eat scabby barley.

There is little difference in the feeding value of varieties. The farmer growing barley for feed ordinarily should use the highest-yielding variety. Other things being equal, the percentage of hull is higher on small-kerneled than on large-kerneled barleys. Feeding tests, however, have shown little difference in the value of the different kinds if they are plump and well grown.

The barley kernel is too hard to use satisfactorily as feed without some previous preparation. Grinding is the most common treatment in the Central and Eastern States. The grain should not be ground finely. Finely ground barley makes a pasty mass when chewed by animals and results in reduced consumption. When grinding barley, the machine should be so set as merely to crack the grain rather than pulverize it. In the West much of the barley is rolled. This is an ideal method of preparation. A jet of steam softens and moistens the kernel so that little loose material results. At the same time the entire kernel is flattened to a soft, easily crushed disk.

When barley is to be mixed with chicken feed the hulls are sometimes removed. This separation need not be complete. The removal of most of the hull increases the palatability for chickens and greatly improves the quality of the feed by reducing the amount of roughage.

VARIETIES OF BARLEY

More than 5,000 varieties of barley have been tested by the United States Department of Agriculture and State experiment stations. Only a few of them are under cultivation on farms. There is a decided advantage in growing a limited number of varieties. Mixtures are a great disadvantage to the maltster, and the fewer sorts grown the less the confusion in marketing. Some of the most important varieties are briefly discussed below.

MANCHURIA, ODERBRUCKER, ODESSA, AND O.A.C. 21

Manchuria, Oderbrucker, Odessa, and O.A.C. 21 are similar in kernel character and are the type preferred by the maltsters of the Mississippi Valley. Although all four are grown in the Northern States east of the Missouri River, the centers of production are distinct. Odessa is largely confined to South Dakota. Oderbrucker is grown most extensively in Wisconsin, Illinois, and adjacent areas in Minnesota and Iowa. Manchuria is more common in western Minnesota and North Dakota, although a selection, Featherston, is grown to a limited extent in New York. O.A.C. 21 is extensively grown in Canada. The acreage of all these varieties has been reduced in the United States because of farm preference for the smooth-awned sorts. The grain of Oderbrucker is the whitest of the lot. Manchuria consists of a mixture of blue and white strains, whereas O.A.C. 21 is a blue strain of Manchuria.

TWO-ROWED

Two-rowed barleys are not grown extensively. Most brewers prefer a smaller-kerneled barley of higher diastatic power. Spartan is grown on some acreage in Michigan and nearby States. Alpha is grown in New York and Pennsylvania. There are scattering fields of Hanna and Hannchen throughout the Plains States. Horn is common in Montana, and there is a remnant of Chevalier in a few localities such as the Salinas Valley of California.

SMOOTH-AWNED

Farmers naturally prefer smooth-awned barleys. The Department of Agriculture and many State stations have tried to breed suitable varieties. The factor of smoothness is complex, and difficulty has been experienced in keeping such barleys uniformly smooth. Several sorts are sufficiently so for commercial purposes, and their yields have been satisfactory. Among those in common cultivation are Velvet, Glabron, and Wisconsin Pedigree 38 in the upper Mississippi Valley. Comfort is grown in Nebraska. Vaughn and Hero have attained a small acreage in California. The former variety has produced high yields in Arizona and the southern plains.

TREBI

Sixteen years ago Trebi was released to farmers of southern Idaho. All that was known then was that it was well adapted to irrigated lands in this area. Since that date it has spread over much of the northern part of the United States and up into Canada. Although its actual field cultivation has not extended east of the Mississippi River, it has produced high yields on experiment-station plots as far east as the eastern part of Canada. The variety is unquestionably one of the most vigorous that has been tested. Despite its low resistance to disease, it has outyielded other varieties in sections to which by any other measure it seems not to be suited. The grain as produced in eastern North Dakota is very different from that of Idaho, but from the standpoint of feed, it deserves consideration. Maltsters of the Mississippi Valley do not like Trebi. Their acquaintance with the variety is limited to that grown in the northern plains and in the western half of the upper Mississippi Valley. Brewers of the Rocky Mountain area may find the Trebi grown in this area satisfactory. This is especially true of that produced under irrigation.

COAST AND ATLAS

Coast was the common barley of the Western States for many years. The original Coast and Atlas, a selection of Coast, are still grown on most of the acreage in California. Coast is common throughout the Western States, and its near relative Stavropol is extensively grown in northwestern Kansas.

CLUB MARIOUT

Club Mariout is limited mostly to California, where it is popular for late seeding.

WINTER BARLEYS

Tennessee Winter and Wisconsin Winter are two of the hardiest winter barleys. They are also high-yielding sorts. Both are bearded. In the Southeastern States hooded varieties are more popular than bearded varieties. The first distribution of hooded winter barleys came from the Tennessee Agricultural Experiment Station. The varieties released from this station have been added to by other southern stations and by natural hybridization occurring on farms. The hooded varieties yield less than the old bearded Tennessee Winter but are preferred by farmers because of the greater comfort in handling.

WHERE TO PROCURE SEED

Most of the varieties recommended are already in wide cultivation. They are most reasonably secured from nearby farmers. Most States have seed-growers' associations from which certified seed can be obtained. The State experiment stations can usually furnish information as to sources. Many local seedsmen carry the more prominent varieties.

DISEASES

Three of the most important diseases of barley for which chemical or cultural treatments are known are scab, stripe, and covered smut.

Scab is largely confined to the Corn Belt. Scab affects the quality of the grain and reduces the yield. Barley with more than a small percentage of scab cannot be used for malting. It is also unsuitable to feed pigs, causing vomiting in extreme cases. If the grain is less heavily infected, the pigs fail to make normal gains. Scabby barley can be fed to all classes of cattle and sheep.

Treatments for scab are largely preventive. Since the disease is carried over on cornstalks and grain stubble, such material should be carefully plowed under before seeding. The disk obviously is no substitute for the plow on stubble land. Fields that were not planted to either corn or small grain the previous year are likely to be free from scab. In scab areas, the seed should be run through the fanning mill before being sown, to remove as many infected kernels as possible.

The grain should be treated with a mercury-dust compound. The only satisfactory method of application is with dusting machines, which can be purchased on the market. The machine should be rotated until every kernel is covered with a film of dust. *All mercury-dust compounds are poisonous. The operators of dusting machines should plug the nostrils with cotton and cover their mouths with moist bandages to avoid breathing the dust.*

Blighted barley is a market problem. Darkened underdeveloped kernels are caused by a wide variety of organisms in addition to that of scab. The effect of many of these are less objectionable than scab, especially for hog feeding. The buyers are often unable to determine the cause of the damage or to distinguish scabby kernels from kernels affected by other organisms. Seed treatments and clean culture reduce the amount of infection of some of these organisms.

Covered smut is the most widely distributed of the important diseases of barley. The total loss due to it is considerable. The percentage of infection varies enormously with season and region. Where covered smut is common, clean seed should be used where possible. If clean seed is not at hand, the farmer should resort to dust treatment. One of the mercury dusts is a logical choice, not only because of its usefulness in treating smut but also because of its effect on scab and stripe, where these are present. All three diseases can be controlled by a single treatment, insofar as seed treatment is effective. The mercury dusts are also effective in treating one form of loose smut. The other forms can be controlled by the hot-water treatment. Because of the serious seed injury that may result, the hot-water treatment is not recommended for use by farmers. County agricultural agents can give suggestions as to sources of chemicals and methods of treatment.

COMMERCIAL FERTILIZERS

Most of the barley crop is grown in sections where commercial fertilizers are not widely used. Individual farmers had best secure information on fertilizers from their State experiment stations and substations.

WHEN, WHAT, AND HOW MUCH TO SEED

The recommendations which follow as to varieties to seed and quantity and time of seeding are in accord with those of the State experiment stations as far as information is available.

Arizona.—In the irrigated valleys of southern Arizona tests at Mesa and Sacaton indicate that Common Six-Row and Vaughn are the most dependable varieties. Sacramento, although late, may be useful on rich soils, as it is resistant to lodging. In southern Arizona barley is seeded in the fall or winter. October seeding is common where the crop is used for pasture. Good crops of grain can be secured from late November and December seedings. At high elevations spring barleys are sown about April 15 to May 15. The rate of seeding for winter pasture is 90 pounds per acre and for grain purposes 60 pounds per acre.

Arkansas.—Selection 6 (C.I.[1] no. 4678), a barley of the Union Winter type, has produced the highest average yield at Fayetteville. It is recommended that the seeding be done the first week in October at the rate of 7 pecks per acre.

California.—Atlas is recommended for the production of malting barley. Where seeding cannot be done until late, Club Mariout is suggested. Vaughn produces high yields; but because it frays considerably when threshed, it is not desired by the maltsters. The best time to seed is from late October until mid-January. A rate of 70 to 90 pounds per acre is sufficient when a drill is used. When broadcast, however, the rate is increased 25 percent.

Colorado.—Trebi is recommended for growing under irrigation. As a nurse crop, Colsess is preferred, as it is less likely to lodge. For the dry-land districts, Club Mariout and Flynn are desirable. Under irrigation 90 pounds is a good seeding rate. The seeding date varies from the first 20 days of April around Fort Collins to the last week in April around Fort Lewis. On dry land the seeding should be done in late March or early April at the rate of 4 pecks per acre.

Georgia.—The most promising variety appears to be Greece. At Tifton, Tennessee Winter Selection 66 produces high yields. Hooded winter varieties have proved unsatisfactory. Barley should be seeded by early October in the northwestern part of the State and by October 25 elsewhere. The rate is 6 to 8 pecks per acre.

Idaho.—Trebi is recommended for growing throughout Idaho. In the Palouse section Winter Club is recommended for winter seeding. Charlottetown 80 is being distributed in cut-over areas. In irrigated sections the seeding rate is 100 pounds per acre. In nonirrigated sections the rate of 6 pecks, decreasing to 4 or 5 pecks in the drier portions, is sufficient.

Illinois.—Wisconsin Pedigree 38 is well adapted for general cultivation. Where stiffness of straw is essential, Spartan is recommended. Eight pecks per acre is the recommended seeding rate. On the southern edge of the barley belt early seeding is very important. Around Urbana barley should be in the ground in late February or early March. The latter half of March is the best time to seed in sections represented by DeKalb.

Indiana.—Only limited areas in Indiana are suited to the cultivation of barley. Wisconsin Pedigree 38 and Velvet are recommended. Spring barley should be seeded as early as possible at the rate of 2 to 2½ bushels per acre. September is the most favorable time for fall seeding.

Iowa.—Trebi and Spartan are recommended for feed. Velvet is recommended for market or feed. Most varieties respond to early sowing. Losses increase rapidly if sowing is delayed beyond the middle of April. Two bushels per acre is a satisfactory rate of seeding.

Kansas.—Stavropol is the old standard barley of western Kansas. There has been some seeding of Trebi in recent years. Vaughn and Flynn are the best of the smooth-awned varieties. Malting barleys produce fair yields but must be handled promptly to avoid shattering. It is recommended that barley be seeded during the last half of March at the rate of 1½ to 1¾ bushels per acre.

Kentucky.—Barley is adapted to limited localities in Kentucky. Union Winter and Tennessee Winter are the most dependable varieties. The grain should be seeded before the end of September at the rate of 2 bushels per acre. Unfortunately, barley cannot be sown late enough to avoid infestation with the Hessian fly.

Maryland.—Tennessee Winter and Wisconsin Winter are good barleys for fall seeding. Winter barley should be in the ground before the end of September. The best rate is 2 bushels per acre.

Michigan.—The 2-rowed varieties, Spartan and Alpha, are recommended. The market demand for barleys of the Oderbrucker type probably can best be met with Velvet and Wisconsin Pedigree 38. Barley should be seeded as soon as the ground can be properly prepared in the spring, at the rate of 1½ to 2 bushels per acre.

Minnesota.—Manchuria (C.I. no. 2330), Glabron, and Velvet are recommended for all sections of Minnesota under ordinary conditions. Trebi is recommended as a feed barley for the Red River Valley, Minsturdi for heavy soils, and Peatland for peat land. For the cut-over district in northeastern and north central Minnesota, Svansota is suggested. Barley should be seeded as early as the ground can be prepared. The recommended rate is 2 bushels per acre.

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[1] C. I. denotes accession number of the Division of Cereal Crops and Diseases.

Missouri.—Trebi is recommended and should be sown in March at the rate of 2 bushels per acre.

Montana.—Trebi and Horn are recommended in Montana. Seeding should be done as early as the season permits and, for dry land, preferably on clean summer fallow. The rate is 8 pecks for irrigated land and from 5 to 6 pecks on dry land.

Nebraska.—Trebi, Glabron, Comfort, and Short Comfort are recommended. Trebi is especially popular under irrigation and for growing where the crop is harvested with a combine. Barley is usually sown at the rate of 2 to 2½ bushels per acre in eastern Nebraska, the rate diminishing materially toward the west under upland conditions.

New Jersey.—Alpha and Velvet are suggested for growing in all sections of the State. The usual rate of seeding is 10 pecks, although for late seeding 12 pecks is probably a better rate. The best date of seeding varies from April 1 in the southern to April 15 in the northern part of the State.

New Mexico.—In southern New Mexico barley may be either fall sown (Sept. 15 to Oct. 15) or spring sown (Feb. 1 to 15). When fall sown, the unnamed variety C.I. no. 4673 produced the highest average yield at State College. It is recommended that both fall and spring barleys be seeded at the rate of 90 to 100 pounds per acre. In northern New Mexico spring varieties are grown. They should be sown in late May or early June at the rate of 1 bushel per acre.

New York.—Alpha (two-rowed) and Featherston No. 7 (six-rowed) are considered useful varieties for the farmer to grow. They should be sown in April at the rate of 2 bushels per acre.

North Carolina.—The farmers of North Carolina prefer the hooded varieties even though they yield less than the bearded Tennessee Winter. Rowan and Tennessee Beardless No. 6 are recommended. They should be sown in October at the rate of 2 bushels per acre.

North Dakota.—Trebi is recommended as a feed barley for most of North Dakota. Manchuria and Velvet are satisfactory market varieties. In eastern North Dakota Manchuria and Velvet should be sown at the rate of 6 pecks per acre. Five pecks are sufficient farther west. For Trebi and other large-seeded varieties, the rate should be higher. The seed should be sown in late April or early May.

Ohio.—Glabron and Velvet are recommended for spring seeding. Most of the barley acreage is in northwestern Ohio. They should be sown at the rate of 2 bushels per acre the first week in April or as soon after that as possible.

Oklahoma.—The winter barleys of Oklahoma have become more or less adapted to the country, and it is recommended that seed be secured locally. Of the smooth-awned sorts, Vaughn has shown some promise. Fall-sown barley should be in the ground by October 15. Spring varieties should be sown between February 10 and March 10. Two bushels per acre is a desirable rate for fall seeding. For spring seeding the rate varies from 5 pecks per acre in western Oklahoma to 8 pecks on the better lands where the rainfall is heavier.

Oregon.—Trebi is recommended for spring seeding and Winter Club (Utah Winter) for fall seeding in the Pendleton area. Flynn fits best into agricultural practices around Moro, although other varieties may produce equal yields. Around Pendleton the seeding should be done between March 1 and 15. On the drier lands seeding should be done as early in the spring as soil conditions permit. Rates of seeding vary in eastern Oregon, being as high as 2¼ bushels in the regions of greater rainfall and less in the drier areas. In western Oregon O.A.C. no. 7 is recommended for fall seeding, for early spring seeding, and for sowing on bottom land. Its selections, no. 1 and no. 6, are more winter-hardy and are more desirable for fall seeding. Hannchen is the best barley for medium and late spring seeding, especially on upland. In western Oregon barley should be sown from October 10 to 30 for fall seeding and April 1 to 30 for spring seeding.

Pennsylvania.—Wisconsin Pedigree 5, Comfort, and Velvet are satisfactory varieties for Pennsylvania. The average date of seeding in the vicinity of State College is about April 24. In southeastern Pennsylvania the most favorable time is about 2 weeks earlier and in the northern counties about 2 weeks later. Two bushels per acre is the usual rate of seeding.

South Carolina.—Beardless and Tennessee Winter are the varieties usually recommended. The latter is superior for pasture and winter grazing where the residue is to be turned under. October is the most favorable month for seeding, and 1½ to 2 bushels per acre is the best seeding rate.

South Dakota.—Odessa is recommended for the eastern part of the State, and Horn, Ace, and Lion × Manchuria for the central area. Trebi should be grown under irrigation in the western portion. Barley should be sown early. Sowings made later than April 15 are likely to produce reduced yields. It is recommended that 6 pecks per acre be sown in the eastern part of the State, and 5 pecks in the central and western sections except under irrigation, where 8 pecks should be used.

Tennessee.—Union Winter has long been a standard variety in Tennessee. Many farmers, however, prefer the hooded sorts, Tennessee Beardless 5 and Tennessee Beardless 6. Barley should be sown the latter part of September or in early October. Eight pecks per acre is the usual rate.

Texas.—Finley or strains of Tennessee Winter are recommended for northeastern Texas, and Vaughn for sections to the west. Winter seeding from November to January is recommended for the San Antonio section. In north Texas winter barley should be sown from October 1 to 20, and spring barley about February 1. Spring barley is preferred in western Texas. In the Panhandle most of the barley is sown about February 15. Winter barley is grown to some extent along the Oklahoma border but frequently winterkills in the Panhandle. The rate of 2 bushels per acre is suggested for northeastern Texas, while 6 pecks is sufficient for most of the areas to the west.

Utah.—Trebi is recommended for the irrigated lands of Utah. It should be seeded in April at the rate of 2 bushels per acre. In the Nephi area, Bulgarian, a winter variety, is the best of many tried. It should be sown in September at the rate of 7 pecks per acre.

Virginia.—Wisconsin Winter and Esaw are recommended for seeding on farms in the Potomac area. Tennessee Winter, likewise, has some market qualities that make it desirable, and it is a logical selection where a kernel similar to Manchuria is desired. Barley should be seeded before the end of September, the best rate being 2 bushels per acre.

Washington.—The leading spring varieties are Beldi Giant, Trebi, and Blue. Winter Club has long been recognized as the most dependable winter variety and is recommended for fall seeding. Barley should be sown as early in the spring as conditions permit. On the drier lands of the Big Bend country, sowing should be done in March or early April. In the better-watered parts of the Palouse, April is the most satisfactory time for spring sowing and the latter part of September for fall sowing. Rates of seeding vary from 5 pecks on the drier soils to 8 pecks on the best of the Palouse.

West Virginia.—The 2-rowed variety, Alpha, has proved to be superior to the 6-rowed sorts in West Virginia. Seeding should be done early in April. About 7 pecks is a desirable rate for Alpha, although 6 pecks is ordinarily sufficient for the 6-rowed varieties.

Wisconsin.—Wisconsin Pedigree 38 is recommended. It is usually sown immediately after the seeding of wheat and oats is completed. This varies from April 1 to May 7, but the average date is about the third week in April. The common rate is 2 bushels per acre, but 1½ bushels is recommended for Wisconsin Pedigree 38.

Wyoming.—Coast and Trebi are recommended for dry land. Where the straw is to be utilized Horn, Smyrna, and Vaughn are suggested. For irrigated conditions Horn and Trebi are satisfactory. Five pecks per acre is the recommended seeding rate on dry land and 8 pecks on irrigated land. The best time to seed is from April 15 to May 1.

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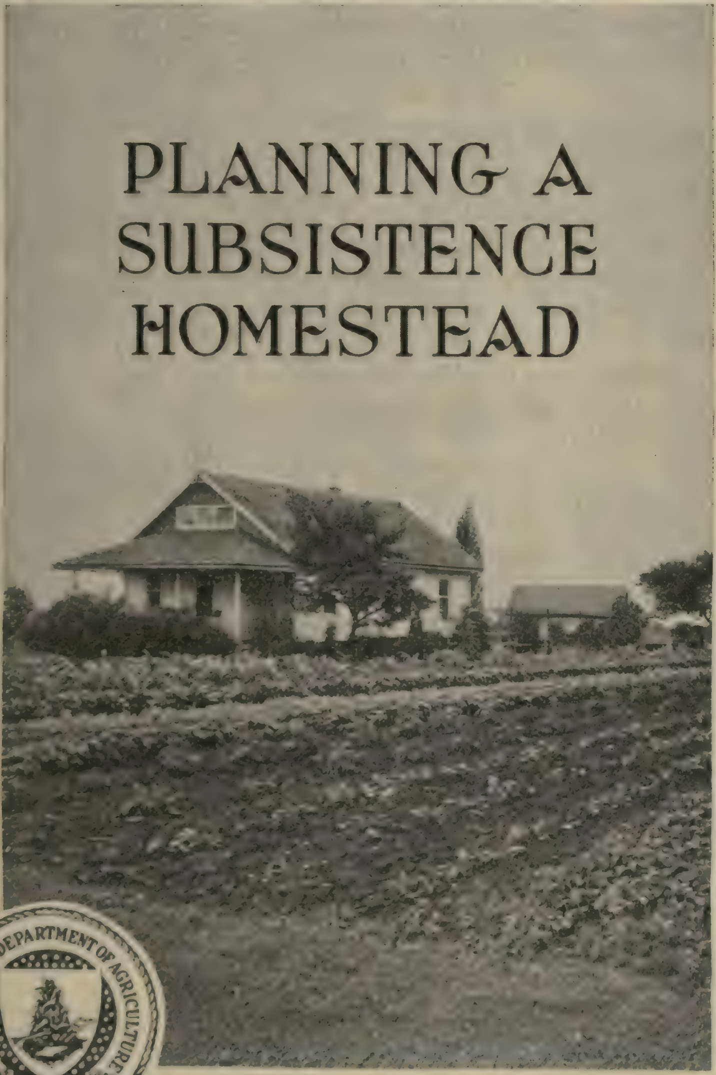
U. S. DEPARTMENT OF
AGRICULTURE

FARMERS' BULLETIN No. 1733

PLANNING A SUBSISTENCE HOMESTEAD



MANY FAMILIES with small incomes can lower their living costs by living on a small piece of land and growing their own food, and at the same time enjoy a greater quantity and variety of fresh and canned vegetables and fruit. Gardening and poultry raising on a small piece of land is about all an employed man and his family can care for by hand. About 1 acre of good land is enough for such purposes.

But if the family wants to keep a cow and plans to buy the necessary winter feed, 2 acres of good pasture land, in addition, should be enough, and the extra work will not be excessive.

Men employed only part time or short hours who have large families and small incomes may find it economical to keep a milk cow, or milk goats, and some pigs, and raise the necessary feed in addition to having a garden and keeping poultry. This plan means the use of horse or mechanical power and should be tried only after experience and careful consideration.

Some families are so placed that their best plan involves obtaining a fairly large acreage of cheap land for general farming. In many areas this cheap land is extremely poor and has failed to yield a reasonable living under any kind of farming. For this reason extreme care must be exercised in selecting a so-called cheap farm.

Washington, D.C. Issued May 1934

PLANNING A SUBSISTENCE HOMESTEAD

By Walter W. Wilcox, *junior agricultural economist, Division of Farm Management and Costs, Bureau of Agricultural Economics*[1]

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RENEWAL OF INTEREST

GROWING FOOD for family-living purposes in connection with enough outside work to provide the family with the cash for necessary farm and family expenses is a combination that many families now want to develop. Recent hard times and still more recent Governmental policies have renewed an intensified interest in this possible combination. This kind of farming has often been called subsistence farming and a farm of this kind a subsistence homestead.

This part-time farming has certain problems of its own that are somewhat different from the usual farming problems. The family has to think of the quantity and variety of products it needs rather than of what the markets demand. Those who are inexperienced often overestimate the savings made possible by this way of living, and they often underestimate the costs in the way of the labor and cash necessary in such part-time farming.

In this kind of farming special attention is given to obtaining just the right area and kind of land; for when much of the work is done by hand, a heavy soil that is hard to work is a great disadvantage. With no power available, and with only a minimum of livestock, keeping unused land free from weeds is a burden.

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[1] Members of the staff of the Division of Subsistence Homesteads, U.S. Department of the Interior, assisted in preparing this publication including its illustrations. W. R. Beattie, senior horticulturist, Bureau of Plant Industry, worked out the detailed plans for the garden and fruit production on the small acreages, and Medora M. Ward, assistant economist, Economics Division, Bureau of Home Economics, supplied the section regarding the winter vegetable and fruit supply for a family of five.

This combination of farming and wage work off the farm, now usually called subsistence farming, is particularly attractive to those families with several children who find it difficult to provide suitable housing and plenty of fresh fruits and vegetables from their small incomes. It is much less attractive if wages from work off the farm are not enough to meet the necessary cash expenses of the farm and the family living. Inexperienced people will find severe competition if they try to raise farm products for sale.

Many people now in town who lived on farms in their childhood inquire about subsistence or "self-sufficing" farming on 20 to 100 acres or more. Many farms that are apparently suitable for such a purpose are now for sale at relatively low prices, but many serious problems are involved in this kind of farming. Only a few of those problems are discussed here as most of them are covered in other Farmers' Bulletins, a brief list of which is given at the end of this bulletin.

This bulletin deals chiefly with the economic problems that will be met by those people who are planning to combine part-time farming and wage earning.

SELECTING LAND NEAR CITIES

Several problems are involved in selecting a small piece of land near a city in which jobs may be found. The first is the difference in the prices of land with reference to location. The price of land near a city is often based as much on residential value as on productive capacity. Two tracts of land equally valuable from the point of view of building sites may not be equally valuable for use in growing fruits and vegetables. A part-time farmer should have good, productive land. The importance of the soil cannot be overemphasized. A moderately level, fertile, well-drained piece of land that is free from stones and can be readily worked may easily be worth twice as much as another nearby tract of the same size. Sandy loam soils usually can be worked earlier in the spring than the stiff clay loams, but crops on the clay loams frequently withstand dry weather better than those on lighter soils. By draining, irrigating, manuring, and the right kind of cultivating any reasonably good soil can be made suitable for the intensive growing of vegetables.

Distance to place of employment and transportation facilities are other important considerations. Studies show that most part-time farmers do not want to drive more than 10 miles to work. Other things being equal, a location near several places where jobs might be found has many advantages over a location where a family would be rather cut off if the one industrial plant closed down.

If city water is not available at a reasonable cost, a good supply of pure well or spring water is necessary. A small tract of land that is otherwise suitable for a subsistence homestead may not have a supply of pure water available because of surface or underground drainage. Public health authorities in the nearby city will test the water for purity or furnish the address of some State official who will do it. Although wells may be drilled at a reasonable cost in most localities, there is always some chance that a supply of good water will not be found near the surface.

In those sections of the United States where the rainfall is scant, it may be necessary to irrigate the crops during at least a part of the growing season. Under such conditions even more attention should be given to the water supply.

The location of the land with regard to community improvements, like roads, schools, churches, and electric-power lines, should also be considered. A part of the cost of some improvements, like paving and sidewalks, is often assessed against the adjoining property. This should be considered when deciding between two tracts of land, if only one has city improvements. The amount of the tax levy for recent years and the probable future taxes should be investigated.

In many cases a small tract of land with a house and outbuildings can be bought more cheaply than it would be possible to buy unimproved land and put up the buildings. But if the chief object is to have a place to raise a supply of food for the family, the quality of the soil should have greater weight than the state of repair of the buildings. In the New England and other eastern States uncleared land on the outskirts of cities is sometimes available at a very low price. Many city people have bought small tracts for home sites, but such land requires a great deal of labor to make it productive. Moreover, care must be taken on uncleared areas to keep rodents and other small-animal pests of agriculture sufficiently under control to insure a full crop.

Small acreages near cities are available for rent. These can usually be rented with the payment of rent on a monthly basis. A year's experience in renting such a place will not only make it possible to decide for oneself on the advantages and disadvantages of living on a subsistence homestead, but it will furnish an excellent basis of judgment as to the advantages and disadvantages of the particular property as compared with some other one located nearby.

If the purchaser hopes to increase his farming later, in order to have produce for sale, he should keep the possibilities of such increase in mind when buying.

VEGETABLE, POULTRY, AND FRUIT PRODUCTION

Enough vegetables and small fruits can be raised on one half to three quarters of an acre of good land to furnish a family of five with all they want during the summer and with plenty for canned, stored, and dried products for the winter. These small fruits and vegetables, together with a small poultry flock and a few fruit trees, are all that can be cared for properly by the ordinary family without a horse or garden tractor, if the man is chiefly employed in some other job during the growing season.

LAY-OUT FOR A SMALL ACREAGE

Figures 1 and 2 give suggested plans for using approximately 1 acre of land. Figure 1 shows a plan that is suitable in the North or Northern States as far west as there is sufficient rainfall. Figure 2 shows a plan adapted to the South or the old Cotton Belt. It is to be emphasized that these plans are merely suggestive. The topography and the quality of land vary so greatly in many localities that the plan for using any plot of land must be adapted to its specific conditions.

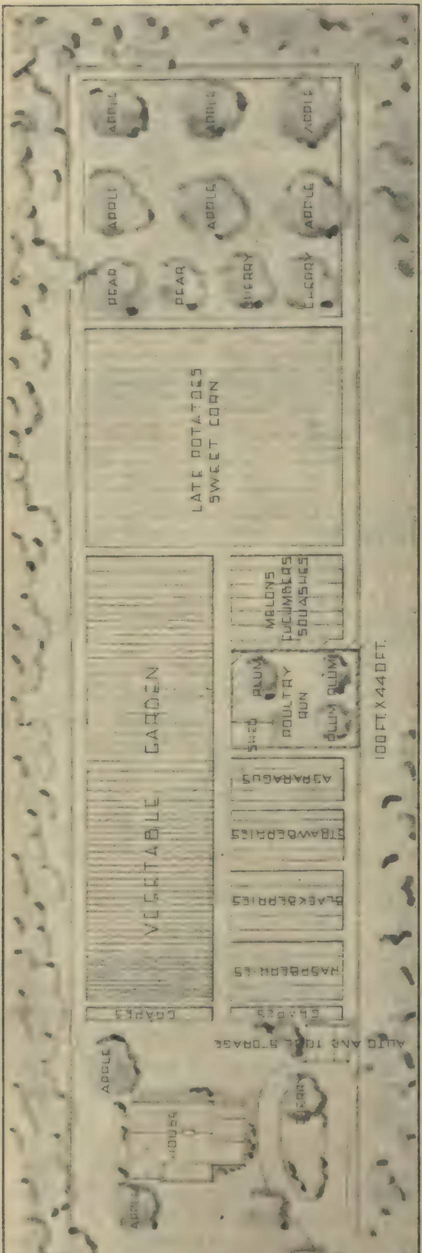

FIGURE 1.—A SUGGESTED PLAN FOR A 1-ACRE SUBSISTENCE HOMESTEAD IN THE NORTH.

Beauty and utility are combined in the lay-out of this tract containing 1.01 acres. In the area north of the Mason-Dixon line and east of the one hundredth meridian this plan provides for a year's supply of vegetables, small fruits, poultry products, early and late potatoes, and most of the necessary tree fruits for a family of five. This is all that a man who is employed elsewhere during the growing season can care for properly by hand with the help of his family.

A few important points are to be kept in mind in planning the home and grounds, regardless of locality. Although the chief object in securing a small acreage may be economy—growing food for the family and lowering the housing costs—beauty or sightliness should not be overlooked when planning the buildings, garden, and tree plantings. Success in changing from a city to a country type of living will depend more on the wife—on her ability and willingness to adapt herself to the new conditions and responsibilities—than on any other member of the family. Careful arrangement of the buildings and plantings will do much to make country living attractive to the family.

Economy of effort is important. The use of the land should be planned so that the work can be done with the least possible effort. This means that the vegetables and berries that need the most attention should be closest to the house. As more trips are made to the garden for small vegetables and berries than for late potatoes, sweet corn, and orchard fruit, the small vegetables and

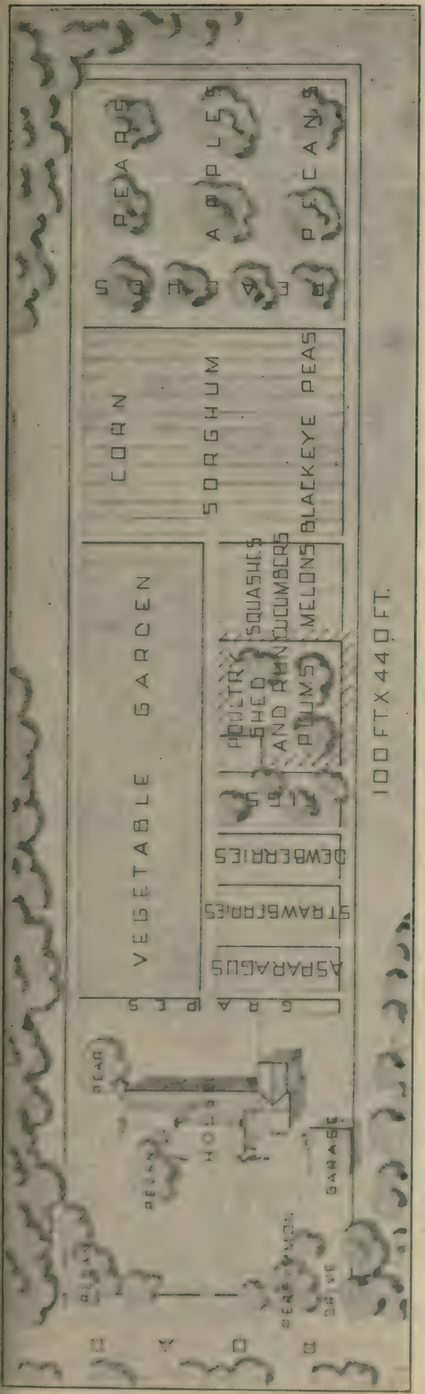

FIGURE 2.—A SUGGESTED PLAN FOR A 1-ACRE SUBSISTENCE HOMESTEAD IN THE SOUTH. This lay-out differs from figure 1 in that it is adapted to that region of the United States often called the old Cotton Belt.

berries should be located nearer the kitchen. If the condition of the land permits, all the cultivated part should be located in one tract to facilitate the preparation of the seed beds and the cultivation. Since poultry requires attention at least twice a day, the chickens should be located reasonably near the house. Trees require the least care and, with the exception of those used for shade, should be located farthest from the house.

QUANTITY AND VARIETY OF GARDEN VEGETABLES AND SMALL FRUITS

Detailed plans for vegetable gardens in the North and South respectively are given in table 1. The amount of each vegetable crop to plant and the standard variety for the general region are suggested, as a guide for those who are not experienced. There may be other equally good or better varieties for any given locality or soil type within the region. The State agricultural experiment station and extension service or reliable garden-seed companies may be able to recommend varieties that are better adapted to specific local conditions.

To be most useful, the vegetable garden must provide a succession of crops throughout the growing season, and a supply for canning and storage for use during the other months. Varieties should be selected with these requirements in mind. With success in growing, the quantity of the various vegetables indicated in the tables will supply an adequate and balanced diet for the average family of five throughout the entire year.

Strawberries do well in most localities and bear fruit the second year after the plants are set out. Some of the better everbearing varieties will produce fruit throughout the fall of the first year. The Klondike and Missionary varieties are best for the Gulf coast region. The Southland, a new home-garden variety, is excellent for other parts of the South. Late summer or early fall is the proper time to set out strawberry plants in the South.

TABLE 1.—*Garden vegetables for a family of five*

IN THE NORTHERN STATES

Crop	Variety	50-foot rows	Succession crop	Distance between rows
		Number		*Inches*
Radishes	Scarlet Globe	1	Fall spinach	18
Lettuce	New York and Simpson	1	do	
Onions	Japanese	2	do	
Beets	Detroit Dark Red	1		
Carrots	Chantenay	2		
Swiss Chard	Lucullus	1		
Parsnips	Hollow Crown	1		
Salsify	Sandwich Island	1		
Peas	Alaska	1	Late beans	30
	Little Marvel	1	do	
	Thos. Laxton	1	do	
	Telephone	2	do	
Snap beans	Early Bountiful	1	Late cabbage	
	Tendergreen	1	do	
	Currie Rust-Proof Wax	1	do	
	Stringless Green Pod	1	do	
Lima beans	Henderson Bush	2		
	Fordhook Bush	2		
Early cabbage	Jersey Wakefield	2		
Broccoli	Italian Sprouting	1		
Early potatoes	Irish Cobbler or Triumph	8	Late cabbage	
Snap beans (2d and 3d planting)	Stringless Green Pod	2		
	Early Bountiful	2		
Tomatoes (early, staked)	Pritchard	2		48
Tomatoes (not staked)	Marglobe	4		
Early sweet corn	Golden Cross Bantam	5	Kale	36
Medium sweet corn	Country Gentleman	5	Turnips	
Late sweet corn	Stowell Evergreen	5		
Pole beans	Kentucky Wonder	1		42
	Pole lima	1		

IN THE OLD COTTON BELT

Crop	Variety	50-foot rows	Succession crop	Distance between rows
Spinach	Savoy	5	Swiss Chard	18
Radishes	Scarlet Globe	1		
	White Icicle	1	Carrots	
Lettuce	White Boston	1		
	Curled Simpson	1	Beets	
Onions (sets)		2		
Onions (plants)	Valencia	2	Fall lettuce	
Beets	Early Eclipse	1		
	Detroit Dark Red	1	Spinach	
Carrots	Chantenay	3	do	
Early turnips		4	do	
Mustard	Southern Curled	3	do	
Early cabbage	Charleston Wakefield	3	Late beans	36
Snap beans	Early Bountiful	2	do	
	Stringless Black Valentine	2	do	
	Rustproof	2	do	
Lima beans	Small bush	3		
Broccoli	Italian Sprouting	2		
Collards	Georgia	4		
Tomatoes (staked)	Marglobe	5		48
Tomatoes (not staked)	do	4		
Early potatoes	Irish Cobbler or Triumph	5	Late turnips (broadcast)	36
Black Eye peas		4		
Sweetpotatoes		17		42
Okra	Perkins Mammoth	2		36
Pole beans	Kentucky Wonder	2		42

From North Carolina northward to the Canadian border the Premier or Howard 17 is one of the most popular strawberry varieties. Two good new varieties, the Fairfax and the Dorsett, are also well adapted to this region. For the northern Great Plains, the Howard 17, Dunlap, and Progressive are among the most popular varieties. The Progressive is an everbearing variety.

Strawberry plants can be set out in the spring in the Northern States and, if given proper care, will yield the second year. They do well in most localities. Some of the better everbearing varieties will produce fruit throughout the fall of the first year. Fifty plants for each member of the family are often recommended as a guide for planting. The strawberry bed should be so located that it can be changed and replanted every 2 years under most conditions.

Grapes bear well in most localities and are relatively easy to care for once the proper methods of pruning and training are learned. They usually reach practically full bearing in the third year after planting. In the Northern States the Concord, Niagara, and Moore's Early are the most popular varieties. In the Southeastern States, the Thomas and Scuppernong varieties are the most popular. About 10 plants set 10 feet apart in the row are plenty for an ordinary family. Grapes require a trellis and careful pruning each year for best results.

Raspberries, blackberries, and dewberries cannot be grown successfully in as large a part of the United States as grapes and strawberries. Dewberries winter kill in the Northern States but are excellent for the South. Raspberries and blackberries do not bear well in the far South. Raspberries, blackberries, and dewberries should bear the second year after planting in those sections of the country where they do well. About 50 to 100 plants of each planted 3 to 4 feet apart in the row should furnish plenty of berries for the ordinary family.

A small asparagus bed should also be found in each family garden and in the North a few hills of rhubarb.

Only a few inexpensive tools are necessary to care for the garden and berries. A good hoe, a garden rake, a spade or spading fork, a pair of pruning shears, and a trowel are all that are essential. Much hard work can be saved if a wheel hoe with a large wheel and a well-built wheel barrow can be bought. Other tools may be useful but are not necessary.

THE SMALL POULTRY FLOCK

Most families who are interested in raising their own vegetables are also interested in producing their own poultry and eggs. Studies in several States indicate that almost all part-time farmers keep a few hens, usually not over 25. A flock of 25 hens can be kept on very little land. They are fed on table scraps and some grain, and thus furnish eggs at low cost for home use. Their manure may be used on the garden land, thus reducing fertilizer cost. A few young chickens can be raised on a different small plot of land each year, in rotation with the garden and truck patch, or on the land planted to young fruit trees. In case the latter plan is used, the young growing trees must be protected.

The necessary permanent buildings and equipment for 25 hens and 40 young chickens would cost about $50 if built with home labor. Temporary buildings made of second-hand lumber and covered with roofing paper may be built for much less. The yearly expense for purchased grain for this number of chickens would be from $25 to $40. If they are well cared for, 25 hens are more than enough to supply the family with eggs throughout the year. In addition, approximately 20 young chickens weighing 3 pounds each and 12 hens weighing 4 to 6 pounds each would be available for meat. This is about 120 pounds of meat of a kind all families like.

There are great differences in the number of eggs produced by the same number of hens under different conditions. Commercial flocks average between 12 and 14 dozen eggs per hen, each year, but the average production in the United States is less than 7 dozen. With good care and housing, the pullets in the flock will lay all winter, but the spring months naturally bring the heaviest laying. It will probably take a few years of experience to get good fall and winter egg production. Eggs are usually lowest in price during the spring and highest in price during the fall and winter. During the heavy laying season in the spring the surplus eggs can be preserved in water glass for use in the winter. On request, the county agricultural agent or the home demonstration agent will furnish, without cost, instructions regarding the use of water glass.

Unless this plan is used the first year or two, it may be necessary to buy eggs in the fall and winter. As in the case of gardening, starting in a small way in egg production is advisable for the beginner. A dozen pullets may be enough for the first year. If the family is successful in getting good egg production from this number, they will have enough fresh eggs for their own use. If good production is not obtained the first year (and this would not be unusual) a larger flock would only mean a larger feed bill.

Losses in the raising of young chickens are likely to be heavy unless the chicks are fed properly and parasites and diseases controlled. To raise only a few chickens the first year will give the needed experience and will keep down the risk of heavy losses.

PRODUCTION OF TREE FRUITS ON SMALL ACREAGES

To grow tree fruits, especially winter apples, may be doubtful economy if the land is high priced and the family has enough cash income to buy these fruits. These trees do not come into bearing for several years; peaches take about 4 years, cherries and plums 4 to 5 years, and apples 6 to 8 years. During this time they must be cared for, sprayed, and pruned if they are to yield well at maturity. A well-rounded program of production for family subsistence, however, should include cherries, plums, peaches, pears, and apples in all localities where such trees bear well.

Bearing fruit trees should be sprayed several times each year, to kill the various insects and to combat the diseases that attack the trees and the fruit. This work is often neglected by those who have only a few trees, as it requires some special equipment, but unless this need is fully realized there is likely to be disappointment later.

A barrel mounted on a 2-wheel cart and fitted with a hand sprayer can be bought or built at a cost of not more than $30. This equipment can be used to spray the trees on 5 to 10 homesteads having 10 to 15 trees each. If the spraying equipment is owned in partnership the cost would be only $3 to $6 for each family.

FERTILIZERS

If the vegetables and other crops are to be cultivated entirely by hand, the intensive use of a small piece of land with heavy fertilization is more feasible and will give better results than the use of a larger area of land in medium or poor condition. Stable or barn-lot manure, when it can be obtained at a reasonable price, is the best garden fertilizer for most soils. A first application of 20 large wagonloads of partly rotted manure on a half-acre garden is not too much, if the land is lacking in organic matter and fertility. However, such manure is usually scarce and expensive near cities. The time to apply the manure will vary, but as a rule it should be spread just before the ground is plowed.

Commercial fertilizers can be used to advantage in many cases along with the manure from the poultry flock. An application at the rate of 600 to 1,200 pounds to the acre, when no manure is available, will usually prove satisfactory. A fertilizer that contains about 5 percent of nitrogen, 10 to 20 percent of phosphoric acid (usually in the form of superphosphate), and 5 or 6 percent of potash is about right for general garden crops. After the ground has been spaded or plowed, the fertilizer should be worked into the ground before the vegetables or other crops are planted.

INSECTS, DISEASES, AND OTHER HANDICAPS

Diseases, insects, rodents, and other pests attack the vegetables as well as the fruits and poultry. These pests, or poor seed, or unfavorable weather may cause a partial or total failure of any one crop or planting. Several plantings help to insure against total loss. A safe plan for the inexperienced is to plant only a small amount of each crop the first year or two. On the basis of the experience thus gained the family can decide which crops are the best for them, considering both what they are successful with and what the family needs.

Even if the first efforts are not successful, the particular crop or variety need not be condemned. Perhaps neighbors have been very successful with it. If so, it probably can be grown successfully if the right methods are used. The county agricultural agent, usually located at the county seat, will be able to give information on all such subjects without cost to the farmers. State agricultural experiment stations will send free bulletins about vegetable growing, insects and diseases, poultry raising, and other agricultural problems, on request. A list of free bulletins published by the Government, which are likely to be of interest to subsistence-homesteaders will be found on page 19.

CASH EXPENSES FOR AGRICULTURAL PRODUCTION AND RETURNS

Cash operating expenses in connection with such a program as outlined in the suggested 1-acre plan would be about as follows:

1 man and team—plowing and preparing the seed bed in the spring (5 hours)	$2.50 to $4
Seeds, plants, and bushes (after first year)	3.00 to 5
Fertilizer (300 to 600 pounds)	4.50 to 9
Insecticides	3.00 to 6
Feed for chickens (1,600 to 2,000 pounds of grain)	25.00 to 40
Total	38.00 to 64

The careful manager can sometimes reduce these cash outlays by exchanging tools with neighbors, by trading work, or by promising to trade products at the end of the season for items obtained earlier.

In return for the family's investment in the land, and its labor and cash expenses for the season, as indicated above, the family will get most of its supply of vegetables for the year, its entire supply of eggs and poultry for the year, and most of its fruit. The value of these vegetables and fruits has been variously estimated at from $70 to $150. If the 25 hens average 8 dozen eggs apiece, valued at 20 cents a dozen, the total value of the eggs produced would be $40; and 120 pounds of poultry meat at 25 cents a pound would be $30. This means that the total value of food from the 1-acre tract would be from $140 to $220.

It might be pointed out that an adequate diet at moderate cost for a very active family of five, as worked out by the United States Bureau of Home Economics, calls for only 85 dozen eggs. This indicates that about 100 dozen eggs would be available for sale if 25 hens are kept, but it would be at the season when egg prices are low, unless unusually progressive poultry practices are used.

WINTER VEGETABLE AND FRUIT SUPPLY FOR A FAMILY OF FIVE

The gardens and fruit trees suggested in the planting diagrams should provide ample supplies for use during the growing season, and also a generous quantity for winter needs. In the North fresh foods will be available for about 4 or 5 months. The southern gardens will produce during a longer period, although in some sections little can be grown during the hot, dry, midsummer months. Early in the year the family should make an estimate of the quantities of the various foods to be stored, canned, and otherwise preserved for use during the nonproductive months. The best method to use will depend upon the crops raised, the climate, and other local conditions.

Storing in cellars or pits is practicable for such relatively nonperishable crops as potatoes, carrots, beets, turnips, parsnips, onions, cabbage, apples, and pears. Sweetpotatoes, after a first curing, must be kept in a dry, warm, well-ventilated place; squash and pumpkin should also be stored in a dry, warm place.

Drying may be used to keep beans, peas, okra, corn, squash, and some fruits; 1 to 2 bushels of dried beans and peas and 15 to 30 pounds of dried fruit is a generous winter supply for a family of five.

Canning, in either glass jars or tin cans, is the best method of preservation for some foods. If proper equipment for canning cannot be bought by single families it may be possible to establish a community canning center where the equipment can be used cooperatively. The Department of Agriculture at Washington, D.C. will send a mimeographed leaflet on community canning centers, on request. A pressure cooker should be used for canning such vegetables as leafy greens, asparagus, beans, peas, okra, corn, or root vegetables. Unless a pressure cooker is available it is advisable to limit the canning to fruits, rhubarb, and acid vegetables, such as tomatoes, tomato combinations, sauerkraut, and beets in vinegar.

The two canning budgets that follow are suggested as general guides for families living in the North and South, respectively. More detailed canning plans based on the conditions peculiar to the individual States can be obtained from the extension services of the various State agricultural colleges or from the local home demonstration agent. The quantities suggested in the following budgets will provide 2 or 3 one-half-cup servings of canned fruits or vegetables for each member of the family for each day of the months when the garden is not producing. Used in connection with the stored and dried products, this amount of canned foods should be enough to meet the usual needs of a family of five. But it might be well to allow an additional 10 to 15 percent to care for guests, spoilage, or emergencies such as poor crops during the following season. As most properly canned food will keep well for at least 2 years, any that is unused may be carried over to use during the second year. It is best not to hold canned foods for longer than 2 years.

During the first few years a new homestead plot may not furnish enough fruit to supply the quantities suggested in the canning budgets. In some sections there may be wild fruits and berries to use. If enough fruit cannot be obtained, the quantities of the various canned vegetables should be increased somewhat.

Fruit and vegetable canning budget for family of 5 in the Southern States

[For use during 7 nonproductive months]

Tomatoes	quarts	100 to 150
Leafy greens (spinach, chard, etc.)	do	20 to 35
Other green vegetables (asparagus, string or lima beans, peas, okra, etc.)	quarts	20 to 35
Sauerkraut	do	15 to 20
Sweet corn	do	15 to 20
Soup mixtures	do	10 to 20
Fruits (peaches, pears, quinces, plums, grapes, cherries, berries, apples, apple sauce, etc.)	quarts	90 to 130
Fruit juices	do	15 to 25
Catsup, pickles, chow-chow, etc	pints	15 to 25
Jellies, jams, fruit butters, etc	do	15 to 25

Fruit and vegetable canning budget for family of five in the Southern States

[For use during 6 nonproductive months]

Tomatoes (if citrus fruits are available the quantity of canned tomatoes may be reduced)	quarts	75 to 125
Leafy greens (fresh greens are available for 12 months in many southern localities).		
Other green vegetables (asparagus, string or lima beans, peas, okra, etc.)	quarts	20 to 40
Sweet corn	do	15 to 25
Soup mixtures	do	15 to 25

Sauerkraut	quarts	10 to 15
Carrots and other vegetables	do	10 to 15
Fruits (peaches, pears, plums, figs, grapes, berries, cherries, etc.)	quarts	75 to 110
Fruit juices	do	15 to 25
Catsup, pickles, chow-chow, etc	pints	15 to 25
Jellies, jams, fruit butters, etc	do	15 to 25

FEED AND LIVESTOCK PRODUCTION ON A SUBSISTENCE HOMESTEAD

If horse or mechanical power is available at a reasonable cost the farm plans can be materially changed to advantage. The garden and truck patch may be laid out in long rows, 3 feet apart, and can be cultivated with power throughout the growing season. This will greatly reduce the hand labor and will permit the use of a larger acreage.

Figure 3 shows a suggested plan for fruit and vegetable production where power is available. Approximately 2 acres of land are included in this plan. Unless some arrangement can be made to secure power cultivation at reasonable cost this plan will not be feasible. To keep a horse or garden tractor for use on such a small piece of cultivated land is questionable economy. A half-acre orchard may not be considered desirable since fruit cannot be gathered for several years. In that case the ground might be used to grow corn or other feed crops for the poultry.

If an orchard is planted as indicated, during the first few years while the trees are young, many of the garden vegetables can be raised in the space between the trees. This would leave some of the other land for growing feed for the poultry.

The one fourth acre sown to legumes in figure 3, if planted to the appropriate crops, may be used in growing the young chickens.

THE FAMILY COW

Studies indicate that a family of five should have from 1,200 to 1,500 quarts of milk and 90 to 150 pounds of butter a year. One good cow can supply these needs most of the time. From the standpoint of an adequate diet for children in families that have very low incomes, keeping a cow would seem to be more valuable than raising vegetables or fruits. But the keeping of a cow by inexperienced people, on a small piece of land has many disadvantages which may make it questionable.

A high-producing dairy cow is a sensitive animal, responding to good care, but quick to give less milk on receiving poor or improper care. Milking, feeding, and watering require regular attention twice each day. But if a family is willing to undertake the regular care of a cow and has a natural knack for taking care of animals it should have no serious difficulties in obtaining a reasonably satisfactory quantity of milk.

Although one good cow, well cared for, will give over 7,000 pounds of milk (the quantity necessary to supply the milk and butter for the family of five), the average production in the United States is only about 4,500 pounds per cow. As the usual lactation period for a cow is 10 or 11 months, at best, milk and butter would have to be bought during part of the year. It is reasonable to estimate that, with ordi-

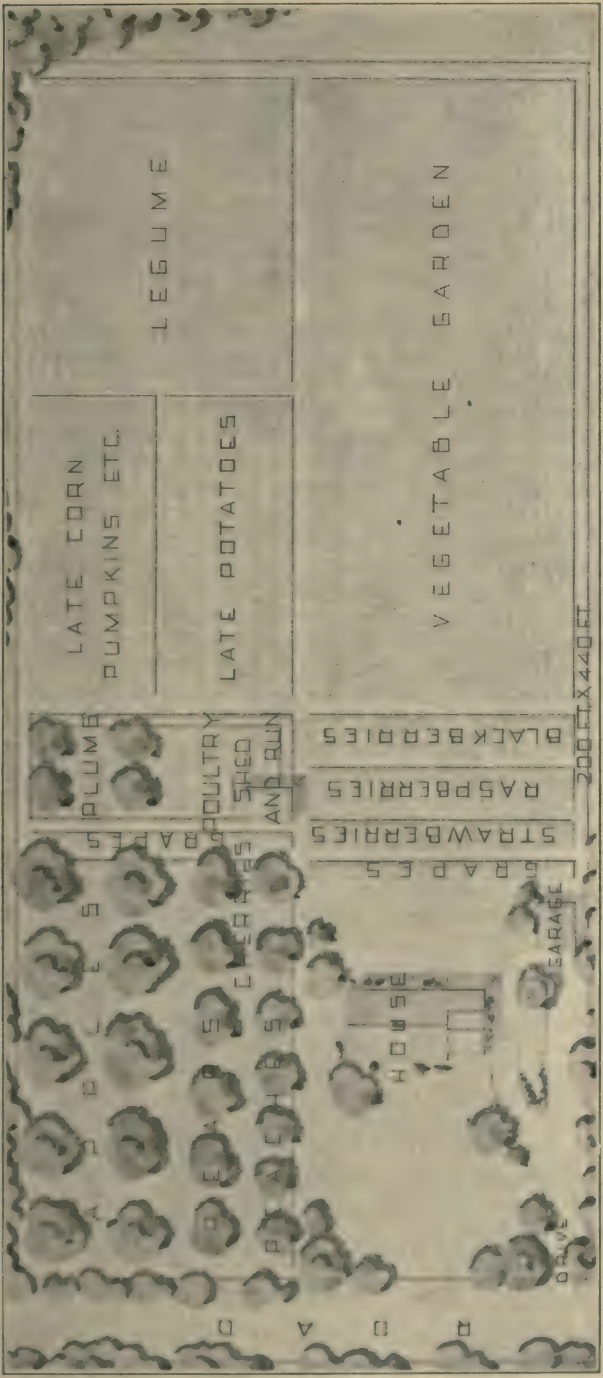

FIGURE 3.—A SUGGESTED PLAN FOR A 2-ACRE SUBSISTENCE HOMESTEAD

Cultivation with horse or tractor power requires wider rows and a larger garden. It also makes it possible to care for a larger acreage. Alternate uses of the space allotted for an orchard and for the rotation of crops are: as pasture for a cow, pasture for milk goats, or pasture for pigs, or for the growing of feed grains for poultry.

nary care, a cow will furnish both the milk and butter for a family of five for 4 months of the year. For another 6 or 7 months there will be plenty of milk, but the butter will have to be bought. Both milk and butter would have to be bought for the remaining 1 or 2 months. If a cow is kept, it may be more economical to sell the extra milk to neighbors and buy butter, rather than try to make butter. The money from sales of milk at retail prices during the first part of the lactation period would not only buy the butter during this period but would largely pay for the necessary purchases of milk during the period when the cow is dry. The question of whether or not to keep a cow may turn on the possibility of selling the extra milk to neighbors at retail prices.

In the Northeastern and Midwestern States, 1 to 2 acres are necessary to pasture a cow. If the land on a 2-acre tract is very productive and no orchard is wanted, enough pasture and green crops could be grown to feed a cow during the summer. A better balanced plan of farm production for family subsistence purposes, however, would be attained by adding 2 acres of pasture to the 2-acre plot suggested above. Figure 4 shows how this might be done, with the pasture arranged so that the cow will come up close to the house for watering, feeding, and milking.

Good summer pasture, supplemented by roughage from the garden, will reduce to a minimum the grain to be fed to the dairy cow during summer months. During the winter in the Northern States a cow will need about 2½ tons of hay, costing from $20 to $38, and from 1,000 to 2,000 pounds of grain, costing from $10 to $30. A shed, built in connection with the poultry house or some other outbuilding, large enough to keep a cow and some feed would cost from $50 to $150. In the South the milder climate makes a warm building unnecessary, but some form of shelter should be provided even there.

MILK GOATS

If for any reason a cow will not be kept, milk goats might be considered in those communities where breeding stock is available. In the southwestern and western parts of the United States in particular, a number of the families on small acreages keep a milk goat or two to supply milk for the family. An ordinary milk goat gives from 1½ to 2 quarts of milk a day and needs only about one sixth as much feed as a cow. Three to five does would be necessary to furnish an ample supply of milk throughout the year for a family of five.

There are a number of things to be learned before buying a milk goat. Farmers' Bulletin 920 on milk goats gives some valuable general information and will be sent free by the United States Department of Agriculture on request. In general, people in this country do not know much about milk goats, but in some communities there may be neighbors who have had experience in keeping goats who can give advice and information.

PORK FOR FAMILY USE

A family of five requires from 400 to 600 pounds of meats and cooking fat a year. This quantity can be produced in the form of pork and lard by growing and fattening three pigs. But most families will not wish to depend on hogs alone for their meat, even though they also have eggs and poultry from their own flock.

In some States and communities there are regulations that prohibit the raising of pigs close to neighbors. In any case, pigs should be kept some distance from any house, even though water and feed must be carried to them.

Two or three pigs can be kept in a small pen and fed table scraps and some grain. Thus they grow into 500 to 700 pounds of live pork at a relatively low cost if the grain can be raised or bought economically. Pigs can be bought as weanlings in most communities for from $3 to $5 each. Pigs immunized against cholera should be bought, particularly if table scraps are to be fed. A pig will eat from 600 to 1,000 pounds of grain costing $6 to $15, while growing to a weight of 200 pounds. Savings of 10 to 20 percent on feed costs may be expected if one fourth to one half of an acre of good pasture can be provided. Shade is very important for pigs in the summer. Plenty of fresh water is also essential. A comparison of the cost of small pigs plus the cost of grain for feed on the one hand and the price of dressed pork on the other, should be made. This, and the effort and risk involved, should be consid-

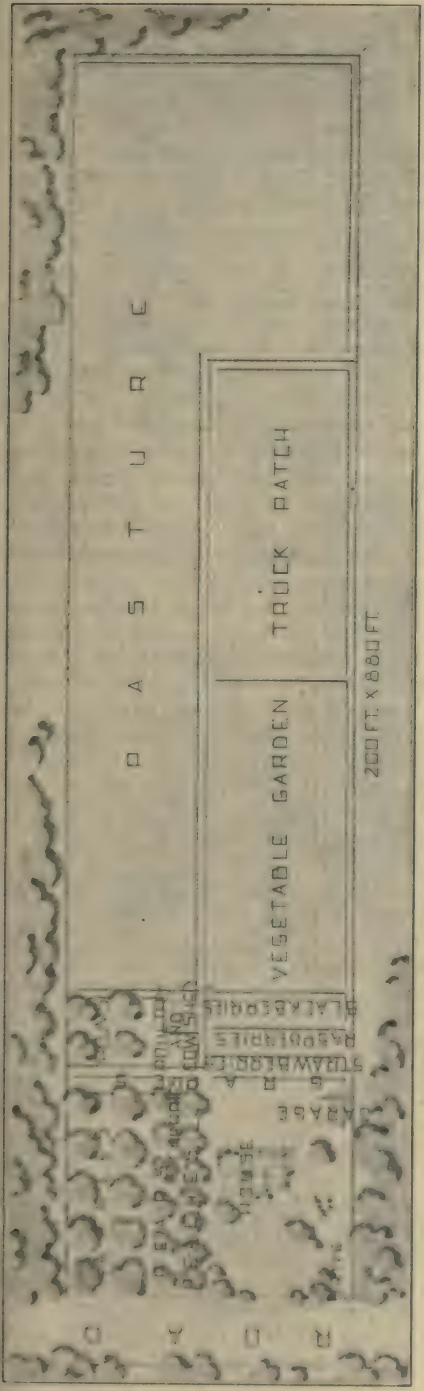

FIGURE 4.—A SUGGESTED PLAN FOR A 4-ACRE SUBSISTENCE HOMESTEAD

The addition of 2 acres of pasture to the plan suggested in figure 3 will provide ample pasture for a cow in those sections of the United States where grass grows well.

ered carefully before a decision is made. Studies of part-time farmers show that only one fourth to one third of these men (mostly on the larger acreages) keep cows and even fewer keep pigs. Evidently most of them find it more economical or easier to buy their milk and meat.

Manure from the animals is valuable for the garden and reduces the cash expenses for fertilizer. Much of the cow manure would be used on the pasture; but even so, fertilizer requirements for the cultivated land should be reduced by 50 to 70 percent when 25 hens, a cow, and pigs are kept.

FEED FOR LIVESTOCK ON SMALL ACREAGES

Many people who want to raise as much of the family's food supply as possible with the lowest cash cost, plan to keep poultry, a cow or two, and pigs, and to raise the necessary feeds. It takes about 1½ acres of land to raise the necessary corn and wheat for 25 hens and 40 young chickens. In addition to 2 acres of pasture for a cow, approximately 1¾ acres are necessary to raise the hay and 1¼ acres to raise the grain consumed by the cow during the year. This makes a total of 5 acres for one cow; if two cows are kept this acreage should be doubled. One and one half acres should produce enough grain to fatten three pigs.

Using 6 acres of land for raising feed in addition to 1 acre of garden and truck crops would require the work of a man and team 15 to 25 days during the growing and harvesting season. If a one-horse outfit were used, 30 to 50 days would be required. This is too small an amount of work for one horse if the overhead cost is to be kept low. On the other hand, to hire a man and team 15 to 25 days at the usual rates means a considerable cash expense.

A horse requires about the same quantity of feed and pasture as a cow. If a horse is to be kept, 5 more acres should be obtained. It might be possible for two or more families to own a horse or team in partnership and thus reduce the cost.

Therefore, if a family plans to do the work by hand an intensive use of a relatively small piece of land will probably be more satisfactory than spreading the effort over a larger area. Unless a cow or pigs are kept, 1 acre of good land is enough under such circumstances. If a cow is kept and it is planned to buy the winter roughage and grain, 2 additional acres of good pasture land would be enough. A man employed elsewhere, working only a few hours a day on his place during the growing season, with the help of his family can care for the vegetable garden, small fruits, a few fruit trees, and a cow without any difficulty.

If mechanical power or horsepower is available at low cost, the vegetables can be grown in wider rows and cultivated with a horse or garden tractor. This makes it possible to put to good use a larger acreage. But it is difficult to have horse cultivation at low cost on a very small acreage. Large families with small incomes, who have considerable free time during the growing season may find it economical to keep a horse, 1 or 2 cows, and some pigs, and raise the farm-grown feeds for the livestock in addition to the vegetables and fruits. At least 15 acres of good land should be acquired in such cases. A careful study should be made of all sides of the question before a family decides to undertake so much farm work for family living purposes. Growing feeds on the farm in such small quantities and the cost of keeping a horse when it is used only a small part of the time mean relatively high costs and low net returns, as compared with the returns from industrial employment, if that is available.

POSSIBILITIES OF A SMALL WOOD LOT

The yearly fuel bill is always difficult for families with small incomes. More fuel is used in country homes where there is no gas or electricity for cooking. If land can be obtained which includes a few wooded acres, the family's wood supply can be provided with almost no additional cash cost. Cutting can be done in the winter or whenever there is extra time, and if the trees to be cut are carefully selected, the supply of timber will continue throughout the owner's lifetime. Perhaps some exchange of work could be arranged with an owner of a team, in order to have the wood hauled to the house. The few acres of woodland may also furnish some pasture for livestock, especially if systematic thinning is practiced.

If the farmer does not buy any timberland but there is considerable timber in the community, he may be able to get the privilege of cutting his fuel supply from a neighbor's woods for a very small sum.

LIMITATIONS OF SMALL ACREAGES AS A MEANS OF SELF-SUPPORT

Letters coming from townspeople show that more often they hear about the best results from farming than about the poorest results; it has therefore seemed best to caution the reader frequently not to regard subsistence farming too optimistically. No real service is rendered in holding out rosy possibilities when the probabilities are slight that such results will be realized by most people. On the other hand it is not intended to discourage those townspeople who are handicapped by lack of capital and are getting only a small income, if they have an honest wish to better their conditions by raising most of their food supply even though it means some trouble and much work.

The work may be hard and the results not always up to expectations; but if the family has no better possibility almost any arrangement to obtain the use of a piece of land should be better than continued idleness or full support from charity or relief funds.

It cannot be overemphasized, however, that a program of farm production as here outlined, even though all the livestock feed is raised, does not make the family self-maintaining. Cash farm expenses must be met, such as the purchase of seeds and feeds that cannot be raised economically, taxes, and repairs of equipment. Family living expenses for clothes, school supplies, and medical care mean cash expenditures. Part-time farming studies do not throw much light on the minimum cash income necessary to meet these expenses. The average cash income reported for those groups of part-time farmers whose financial relations were studied varied from $400 to $900 in most cases.

A number of people, after gaining farm experience, will find that they can raise some products for sale at a profit. A commercial poultry business large enough to employ a man full time and bring in an adequate income can be developed on as little as 2 acres if conditions are right.

PRODUCTION FOR HOME USE ON LARGER ACREAGES

Many people in towns who have little hope of further employment, because of age or for other reasons, would like to get a larger acreage of cheap land on which they can become independent for the rest of their lives. They are chiefly interested in producing for home use; they are interested in producing for sale only enough to furnish the few necessities of life not obtained on the farm. Usually their capital and experience are so limited that cheapness of land is their chief concern. They are naturally attracted by advertisements describing farms that can be bought for a fraction of the cost of the improvements on them.

As a matter of fact, a great deal of farm land in the United States is not productive enough to be of value in growing market crops and livestock. This is especially true in the southern Appalachian region, the Ozarks, the New England States, and the cut-over areas of the Southern and Great Lake States. Many farms in these areas have very low producing possibilities, and the families on them grow crops and livestock almost entirely for their own use.

SELF-SUFFICING FARMS

The 1930 agricultural census, in its study of types of farming, classified all farms as self-sufficing where 50 percent or more of the value of the farm products was consumed by the family. This group of farms, 498,019 in 1929, compares with the type of farming many townspeople propose to engage in. These self-sufficing farms are most common in the southern Appalachian region. Figures from a study of 151,000 of these self-sufficing farms in this region show how meager a living those people really had.

Most of the farms were from 20 to 100 acres in size. The average value was $2,029. The value of tools and machinery per farm was only $74. Not all of the farms had horses; only a little over one half of them kept milk cows; and about one half of them kept hogs. The total value of the farm products sold, traded, or used by the operator's family, in 1929, was $464, of which $323 was used by the operator's family.

INDIVIDUAL FARMS VARY IN PRODUCTIVITY

Studies indicate that the opportunities or likelihood of making a living on some of the farms in these poorer areas is very limited. A full set of buildings is no indication of a productive farm. Many abandoned farms, several hundred acres in size, have failed to yield a reasonable living under any type of farming. Many families living in these areas have another source of income, such as cutting wood for sale, road work, or coal mining, which supplements their living obtained from the farm.

Natural productivity of the soil varies greatly. To the inexperienced, good and poor soils in these regions look alike. The county agricultural agent located at the county seat will be able to appraise the relative productivity of the various farms in his county. Neighbors who have lived in the community for years should be consulted. Inquiry as to how they are farming and the results they are obtaining on their own farms, as well as the results to be expected on nearby farms for sale, may bring valuable information.

Social considerations should form an important part in making a decision. Good schools and churches and desirable associates for the growing children are always considered by responsible parents when buying a home whether in town or country. In general, the communities on poor land are not likely to be able to have good schools and churches. If there are no growing children in the family less consideration need be given this question, and if money is extremely limited it may be impossible to do much about it. But these social problems should not be overlooked.

Buying a farm entirely by correspondence is especially full of dangers. A thorough investigation before buying in unfamiliar areas will prevent many mistakes. Renting for a time before buying gives a family a chance to learn the advantages and disadvantages of any particular farm.

FARMERS' BULLETINS OF INTEREST

The following Farmers' Bulletins published by the United States Department of Agriculture deal with many of the problems encountered in agricultural production for family subsistence purposes. They are available for distribution on request.

F.B. 1673. The Farm Garden.
F.B. 1371. Diseases and Insects of Garden Vegetables.
F.B. 1508. Poultry Keeping in Back Yards.
F.B. 1652. Diseases and Parasites of Poultry.
F.B. 1610. Dairy Farming for Beginners.
F.B. 920. Milk Goats.
F.B. 1471. Canning Fruits and Vegetables at Home.
F.B. 879. Home Storage of Vegetables.
F.B. 1088. Selecting a Farm.

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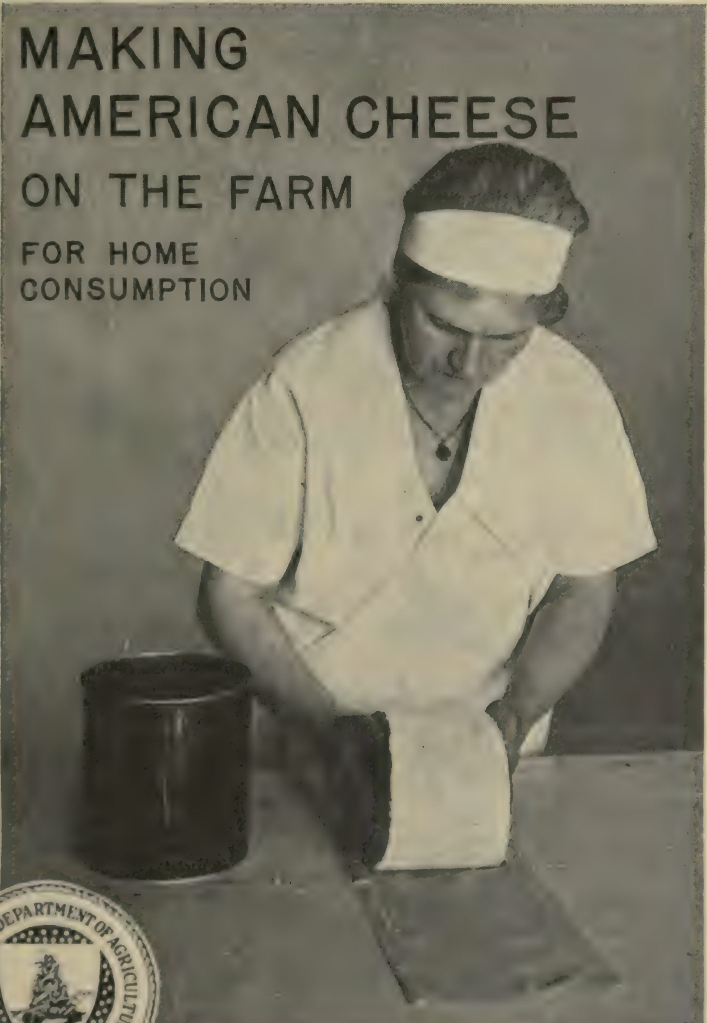
U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1734

MAKING AMERICAN CHEESE ON THE FARM

FOR HOME CONSUMPTION



AMERICAN CHEESE is a palatable and nutritious food. It furnishes abundant muscle- and body-building materials of the kind required by an active, vigorous life. The farm family especially could well afford to eat more cheese for its food value as well as for its appetizing flavor.

Cheese may be made at any time of the year, and making it does not require a great deal of time. Making small quantities of milk into cheese occasionally, or in seasons of the year when there is a surplus of milk on the farm, offers a desirable means of introducing variety into the diet of the farm family and also a means of conserving the milk for use later.

By following the directions given in this bulletin, cheese satisfactory for home use can be made on the farm with simple equipment that is usually available on the farm.

This bulletin supersedes Farmers' Bulletin 1191, Making American Cheese on the Farm.

Washington, D.C. Issued October 1934

MAKING AMERICAN CHEESE ON THE FARM FOR HOME CONSUMPTION

By H. L. Wilson, *associate dairy manufacturing specialist, Division of Dairy Manufacturing Investigations and Introduction, Bureau of Dairy Industry*

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INTRODUCTION

FOR making small quantities of American cheese on the farm for home consumption the factory method, or Cheddar process, is not recommended. The simpler and shorter method known as the stirred-curd or granular process, described in this bulletin, is more suitable on most farms. All equipment, with the exception of a thermometer, necessary for making cheese by this method is usually available on the farm.

The method described in this bulletin is being introduced and demonstrated in many communities by home demonstration agents and State dairy extension specialists.

EQUIPMENT AND SUPPLIES

The following equipment and supplies shown in figure 1 are required:

- One floating dairy thermometer.
- One large dish pan, tinned lard can, or wash boiler.
- One knife with a long blade.
- One wire egg whip with cross wires.
- One strainer.
- One 2-quart dipper.
- One teacup.
- One tablespoon.
- One teaspoon.
- One cheese hoop and bandage.
- One press.
- Rennet extract or rennet tablets.
- Cheese color.
- Salt.

A floating dairy thermometer, rennet extract or rennet tablets, and cheese color can be purchased from any dairy-supply house. Rennet and cheese color tablets can also be purchased at most drug stores, and for this reason are often used in farm cheesemaking. Butter color should not be used because it colors only the butterfat.

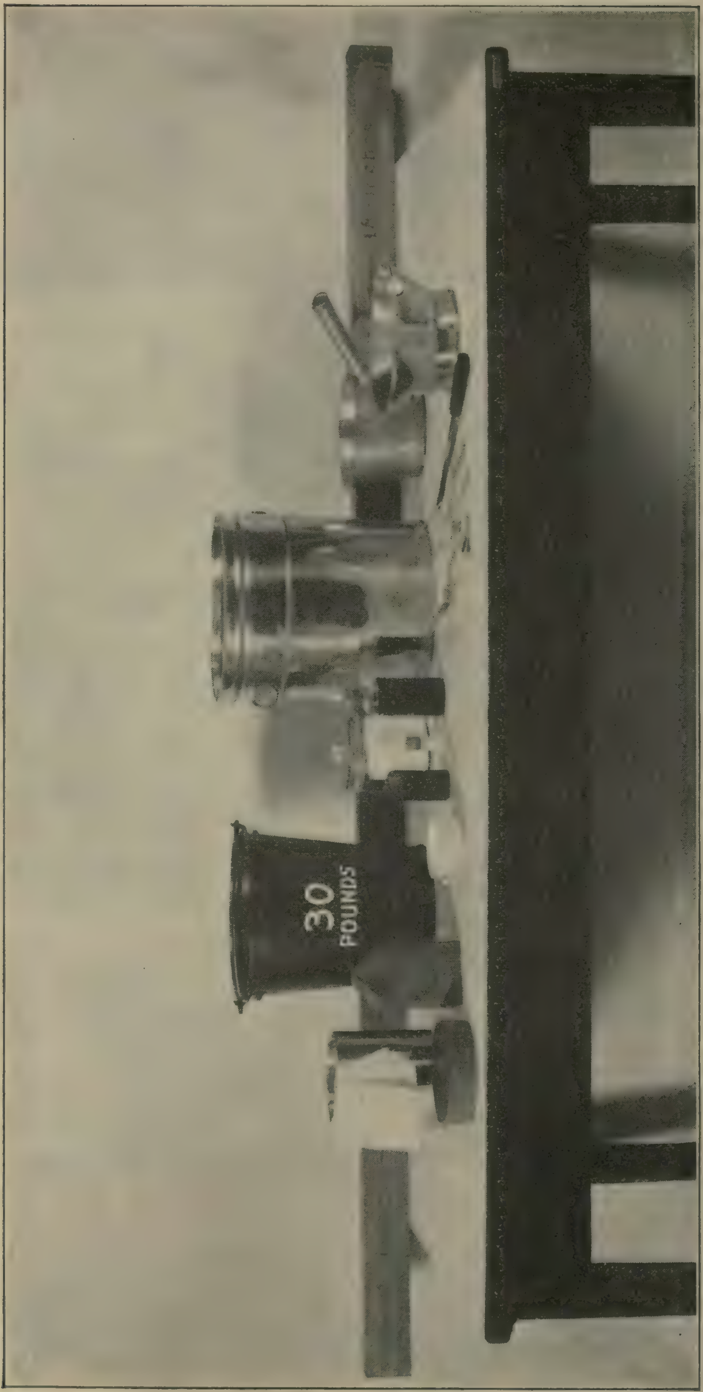

FIGURE 1.—Equipment and supplies needed in making cheese.

Ordinary table salt is suitable for salting cheese, but a high grade of coarse salt is preferable because it dissolves more slowly and more of it is absorbed by the curd.

A small cheese hoop can be made from an ordinary 1-gallon tin pail having straight sides by punching about a dozen small holes in the bottom with a 6-penny nail. A round wooden follower of slightly smaller diameter than the inside of the pail should be sawed out of dressed lumber. Only wood that is free from gummy, acid, or other objectionable substances should be used; otherwise the cheese will become tainted.

Figure 2 shows a press that can be easily made. It consists of a table or bench, a 2 by 4 or a 3 by 3 about 7½ feet long, a pressing block, and a 30-pound weight.

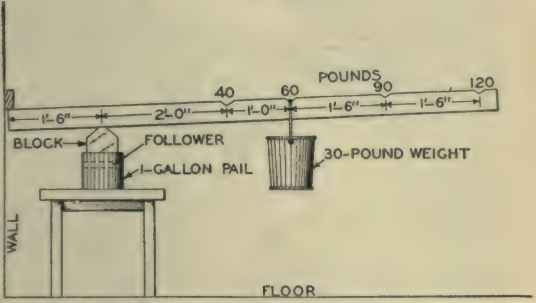

FIGURE 2.—A home-made cheese press.

KIND OF MILK TO USE

It is best to use whole milk for making American cheese on the farm. Milk from which butterfat has been removed or to which skim milk has been added will not only result in poorer quality cheese but in less cheese per hundred pounds of milk. The yield of cheese from 100 pounds (11⅔ gallons) of whole milk is approximately 12.5 pounds for milk that contains 5 percent butterfat, 10.6 pounds from 4-percent milk, and 8.3 pounds from 3-percent milk.

CLEANLINESS OF THE MILK AND UTENSILS

In order to guard against dirty and off-flavored milk, the cows should be kept clean and the milking done in a place that is free from dust and objectionable odors. The milk should never come in contact with unclean utensils; therefore all utensils should be washed and scalded immediately after they are used, and when cheese is not made every day they should be washed and scalded again before being used.

Wear only clean clothing while making cheese; wash the hands well before starting, and keep them clean. Demonstrators should wear a clean white suit, and emphasize the necessity for cleanliness in handling the milk from the time of milking until the milk is made into cheese.

PREPARING THE MILK

A certain amount of lactic acid in the milk is desirable. In commercial plants a pure culture of a lactic-acid-producing organism, or starter, is added to the milk to bring about the production of the desired acidity. However, in making cheese at home it is not usually practicable to maintain a lactic-acid-producing culture. In order to attain to some degree the acidity that would be developed with the aid of a starter at the end of the making process, fresh milk should be cooled to about 60° F. and held 3 to 4 hours before cheesemaking is started. When the night's milk can be cooled to 60° and maintained at that temperature until the following morning, it can be mixed with the morning's milk and the cheesemaking process started at once. When only milk that has stood over night is used, it may contain too much acid unless it has been cooled properly, and the cheese is apt to have a pasty or mealy body and an acid flavor.

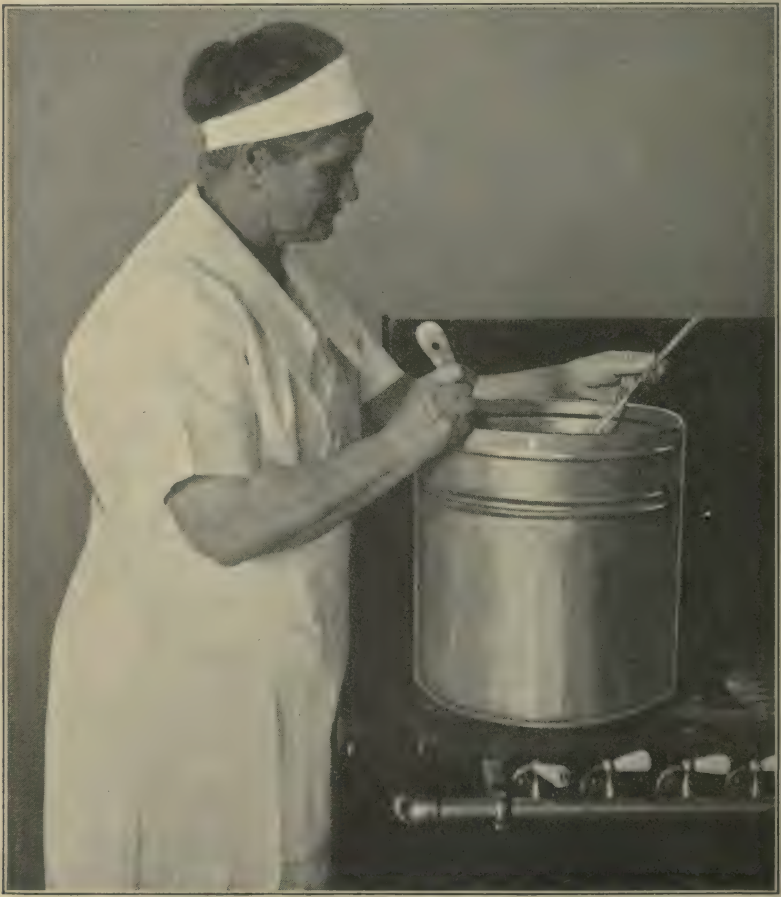

FIGURE 3.—Heating the milk.

On the other hand, if only fresh morning's milk is used, the cheese may have a weak body and may not develop the flavor characteristic of American cheese.

When the necessary preparations for making the cheese have been completed, the morning's milk is mixed with the night's milk in the container in which the curd is to be made. Then the milk is heated to 86° F., as shown in figure 3, by setting the container on a stove. If the heating is done on a wood or coal stove, the grate in the oven should be placed on top of the stove, so that the milk container will not come in direct contact with the hot metal. A gas stove or an oil stove can also be used. The milk should be stirred slowly while it is being heated. When a temperature of 86° has been attained, remove the container from the stove or place it on the back part of the stove so that the temperature will not continue to rise.

ADDING THE CHEESE COLOR

At this point a coloring agent may be added to the milk. Cheese made during the winter months without the addition of coloring matter is practically white. When it is made in the summer months it has a light straw color. If a deeper shade of yellow is desired, cheese color should be used. From one-half to one teaspoonful of coloring agent for each 100 pounds of milk should be diluted in a teacupful of water, and then stirred into the milk until it has been evenly distributed. If color tablets are used, follow the directions given on the box.

ADDING THE RENNET

Now, with the milk at 86° F., add enough rennet to coagulate the milk into a firm jellylike curd in about 30 minutes. When rennet extract is used, usually from 2 to 4 teaspoonfuls will be required for each 100 pounds of milk. Dilute the extract in a pint of cold water and mix the solution thoroughly with the milk, as shown in figure 4. If rennet tablets are used, the directions on the container should be followed. After the rennet has been added and thoroughly stirred in, allowing about 3 minutes for mixing, the milk must remain undisturbed until after it has coagulated; otherwise the curd will be broken and grainy, and whey will separate from the curd before the curd is ready to be cut. The container should be covered during this period to retard the cooling of the surface of the milk.

CUTTING THE CURD

When the curd becomes firm and jellylike, cut it into cubes about three-eighths of an inch square. A method often used to determine the desired condition for cutting is to press on the curd near the edge of the container with the back of the hand, as shown in figure 5. If the curd breaks away cleanly from the side of the container it is ready to be cut. Another method is to insert the forefinger obliquely into the curd, then split the curd with the thumb, and raise the finger slowly, as demonstrated in figure 6. If the curd is ready to be cut, the curd over the finger will split cleanly, and clear whey will fill the opening.

With a clean knife that is long enough to reach from the surface of the curd to the bottom of the container, the curd may be sliced crosswise into strips three-eighths of an inch wide and then lengthwise in the same manner (fig. 7), so that oblong pieces three-eighths of an inch square are formed. The curd should then be carefully stirred for about 2 minutes with a wire egg whip, which has cross wires, or until it has been cut as uniformly as possible into cubes about three-eighths of an inch square (fig. 8). The curd should then be stirred with a large spoon or paddle to prevent further cutting or breaking of the curd. In about 15 minutes, or when sufficient whey has been expelled from the curd to separate the cubes of curd, it is time to begin heating.

HEATING THE CURD

The heating may be done by setting the container back on the stove. The temperature of the curd and whey should be raised slowly; about 2° every 5 minutes until a temperature of from 100° to 106° F. is reached. The curd should be kept in motion with a spoon or other suitable stirrer throughout the heating period to prevent the cubes of curd from sticking together and forming lumps. Lumps will contain more whey than the smaller pieces of curd, and may result in light-colored spots in the finished cheese. The temperature of the curd and whey is raised to from 100° to 106° in from 30 to 40 minutes. At the end of this period the curd is much firmer, and will require less stirring to prevent lumps during the rest of the time that it remains in the whey. The final heating temperature

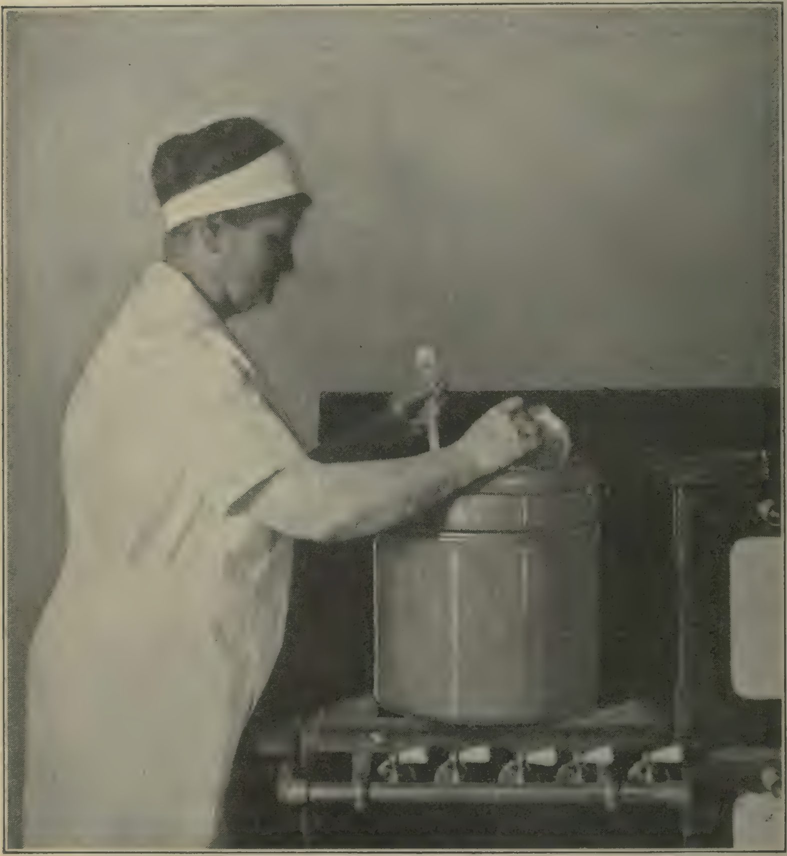

FIGURE 4.—Adding color and rennet.

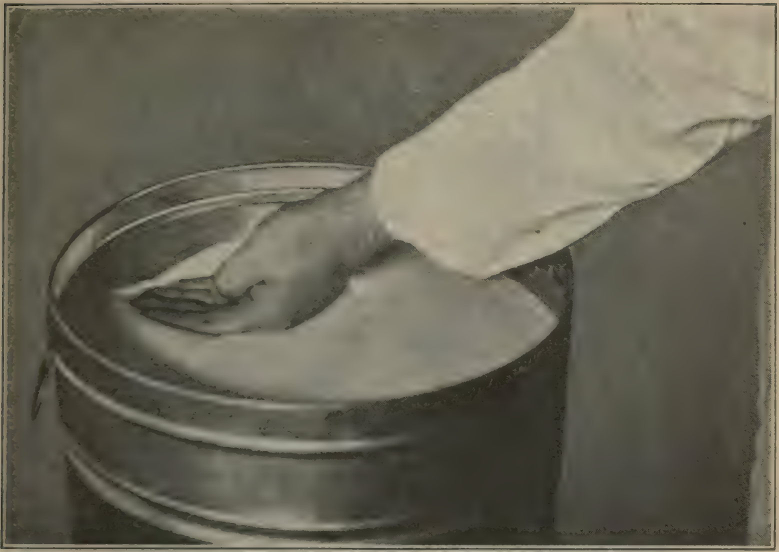

FIGURE 5.—Testing the curd by pressing with the back of the hand.

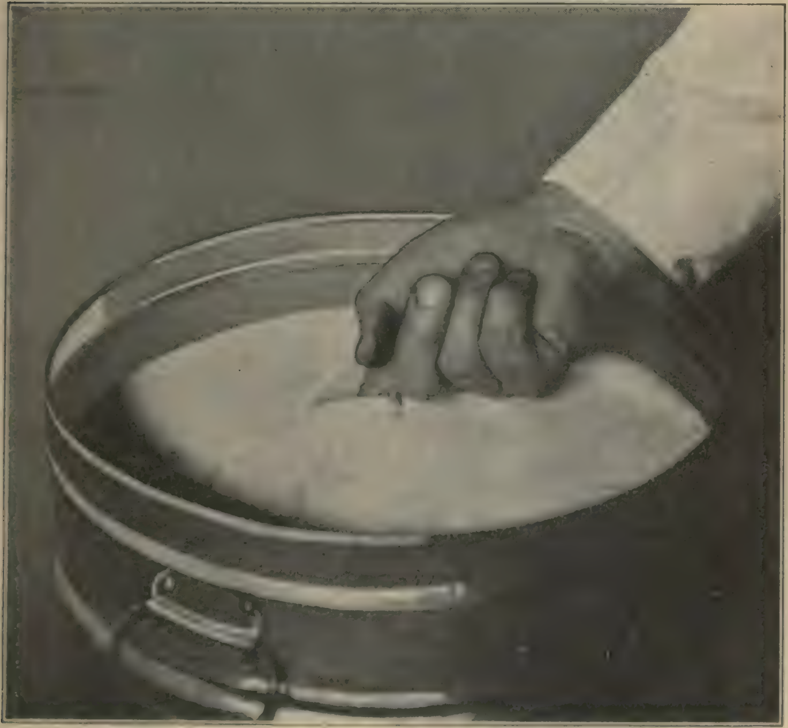

FIGURE 6.—Testing the curd with the forefinger and thumb.

should be maintained until the curd has attained the desired degree of firmness.

At this time a handful of curd gently squeezed and suddenly released should easily break apart and show very little tendency to stick together. From 1½ to 2½ hours after the addition of the rennet the curd should have this characteristic. In appearance it should be similar to that in the strainer in figure 9.

The whey can then be removed. This is the most critical stage in the whole process. If the curd is not firm when the whey is removed, the cheese may have a weak pasty body, may develop sour or undesirable flavors in a short time, may not hold its shape, and will make cheese of inferior quality. On the other hand if the curd is too firm the cheese will be dry and corky.

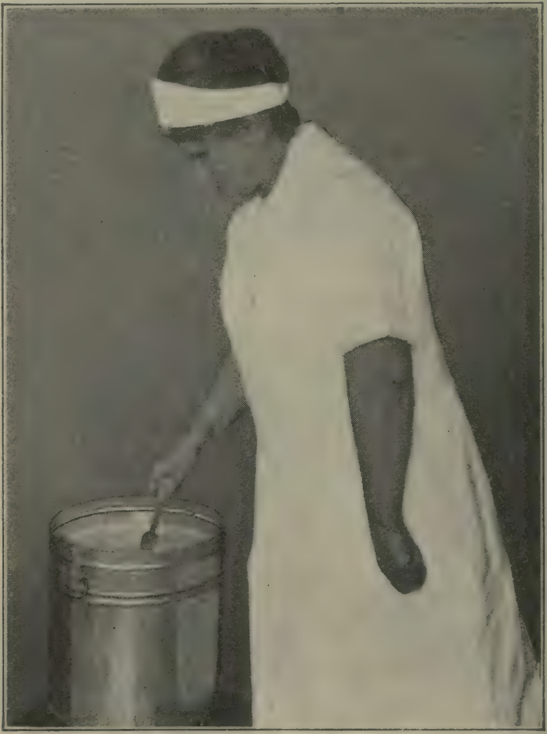

FIGURE 7.—Cutting the curd.

REMOVING THE WHEY

The most convenient and quickest method of removing the whey is to dip off most of it (fig. 10) after the curd has settled to the bottom of the container. Then the remainder of the whey and the curd can be dipped or poured on a rack covered with cheesecloth and placed over a dishpan (fig. 11) or other receptacle for the whey.

The curd can then be put back in the container. The container should be tilted (fig. 12) to allow any whey remaining in the curd

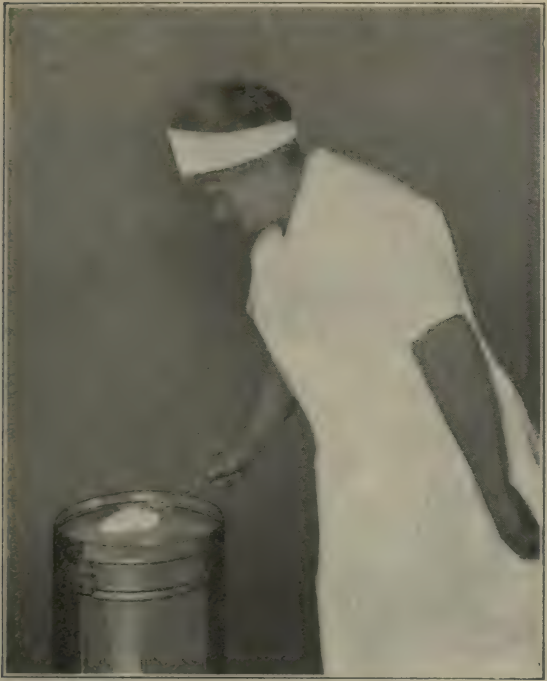

FIGURE 8.—Stirring the curd with a wire egg whip to form cubes.

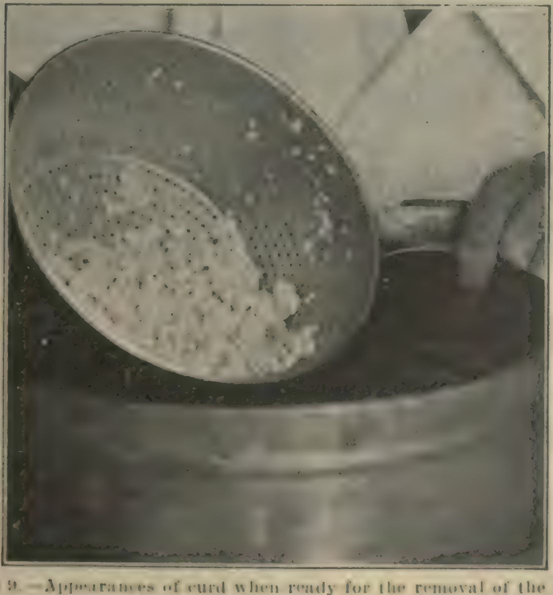

FIGURE 9.—Appearances of curd when ready for the removal of the whey.

to drain away from the curd. The curd should be stirred and kept free from lumps. When the curd has cooled to 90° F., and has a slight acid development which is indicated by a rubbery texture and causes a squeaky sound when chewed, it is ready to salt.

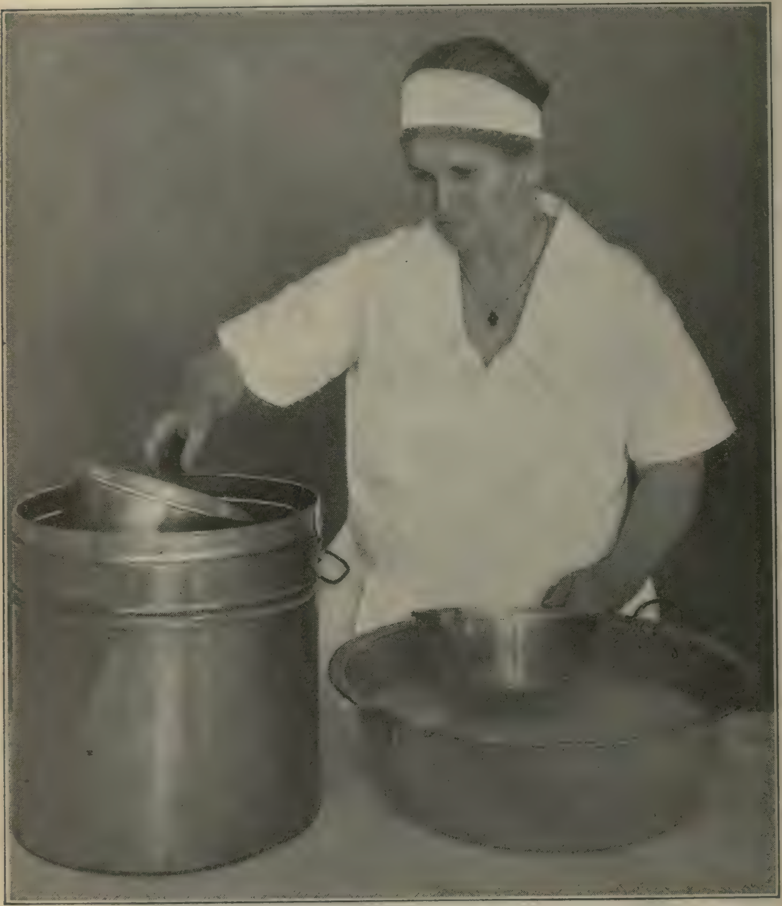

FIGURE 10.—Dipping off whey

SALTING THE CURD

The curd should be salted at the rate of 7½ tablespoonfuls per 100 pounds of milk used. The salt should be distributed evenly and mixed thoroughly with the curd, as shown in figure 12. As soon as the salt has dissolved and the curd has cooled to about 85° F. with stirring, it is ready to be placed in the cheese hoop. If the curd is put in the hoop at too high a temperature an excessive amount of fat will be lost. The higher temperature also favors undesirable fermentation.

HOOPING AND PRESSING THE CURD

In making small prints of cheese that weigh from 5 to 10 pounds, the cheese hoop need not be lined with a bandage when the curd is first placed in it. A circle of medium-weight, unbleached, cotton cloth, known as a cap cloth, of the same diameter as the hoop should be placed in the bottom of the hoop. Then the curd is placed in the hoop and a similar cap cloth laid on top of the curd. A wooden follower of the same diameter as the inside of the hoop is then placed on the curd, and the cheese is put in the press.

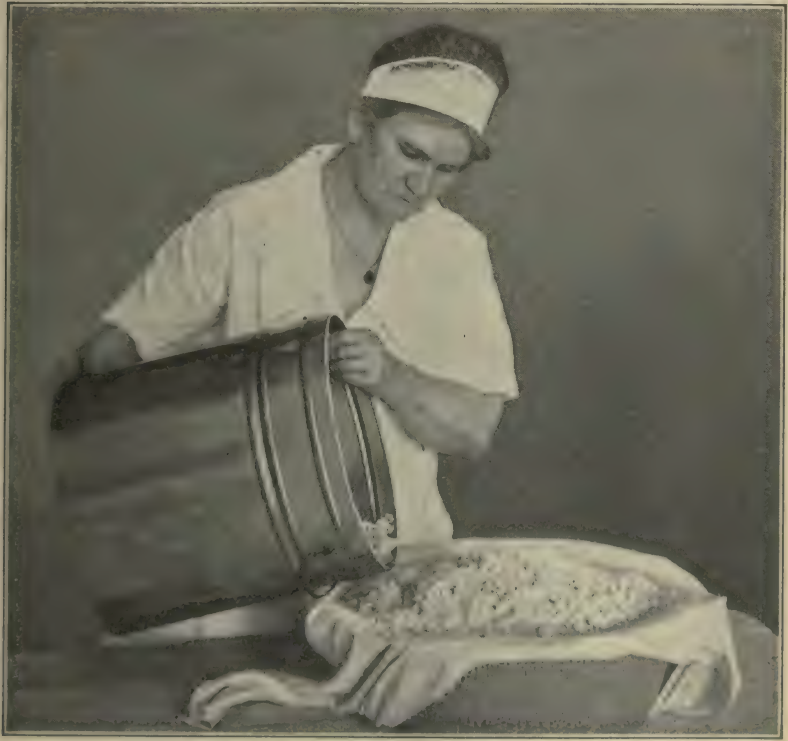

FIGURE 11.—Removing the rest of the whey.

About 40 to 60 pounds pressure should be applied by adjusting the weight on the lever shown in figure 2. After 5 or 10 minutes increase the pressure to 90 or 120 pounds, depending on whether a 5-pound or 10-pound cheese is being pressed. A large cheese requires more pressure than a small one. After the cheese has been under pressure from 30 to 60 minutes it is ready to be dressed.

DRESSING THE CHEESE

Release the pressure and turn the hoop bottom side up on a table so the cheese can drop out. Remove the cap cloths and dip the cheese in a pail of warm water (at 100° F.) to remove any fat adhering to the surface. At this time a bandage of lightweight, unbleached, cotton cloth (see cover) which is wide enough to lap over the edge about 1 inch, should be wrapped tightly around the cheese (fig. 13). The cap cloths should then be replaced (fig. 14) and the cheese put back in the hoop (fig. 15) and pressed for 16 to 24 hours under a pressure of from 100 to 120 pounds (fig. 16).

REMOVING THE CHEESE FROM THE PRESS

At the end of the pressing period, the cheese should have a surface that is smooth and free from cracks or openings (fig. 17). If there are any openings or cracks the bandage should be removed, the cheese dipped in warm water to soften the rind, then rebandaged and put back in the press. A cheese should never be put on the shelf until it has a sound rind. Openings on the surface of cheese make excellent places for molds to grow. Mold on the surface will not cause serious trouble if there are no openings through which it can enter the cheese. When the cheese is taken from the press and its surface is smooth and free from openings it should be wiped off with a clean, dry cloth, and placed in the curing room.

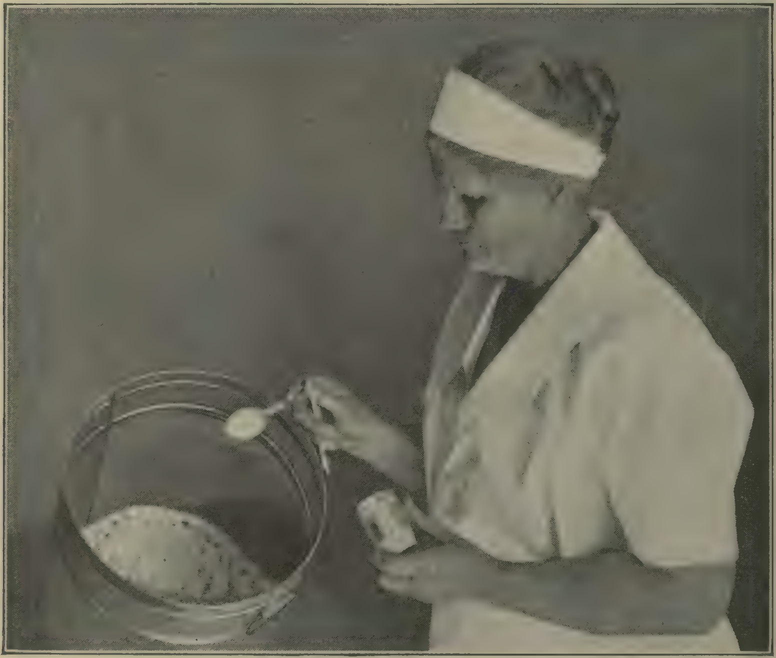

FIGURE 12.—Salting the curd.

THE CURING ROOM

The most suitable place for curing cheese on the farm is usually in the basement of the house or in the spring house. A temperature of from 50° to 60° F. is most desirable but is very seldom available on most farms during the summer months. The cheese should be cured in the coolest available place that can be kept clean and free from molds. The windows should be opened at night to allow cool air to enter and closed in the daytime to keep out the warm air.

The doors and windows should be screened and covered with cheesecloth to keep out the cheese fly, which is much smaller than the house fly. The house fly will do no particular damage to the cheese. If the cheese fly is allowed access to the curing room, it will cause the curing room to be infested with cheese mites or "skippers" and may cause a total loss of some of the cheese. If the room and shelves are kept clean and free from grease and the cheese has a sound rind that is free from openings, the cheese fly will not have a desirable place to lay its eggs.

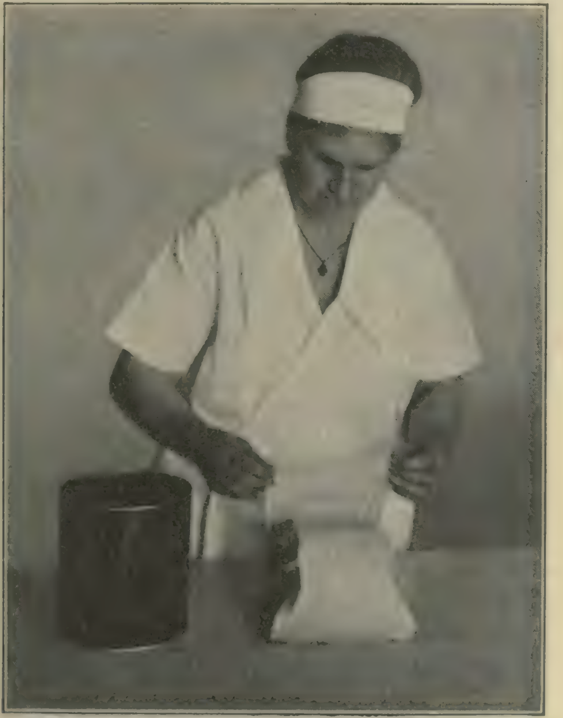

FIGURE 13.—Wrapping the bandage around the cheese.

CARE OF THE CHEESE WHILE CURING

The care of American cheese from the time it leaves the press until it is cured or ready for consumption is very important.

If a basement or spring house is used for curing the cheese, the humidity may be high enough so that all the bandages can be taken off before the cheese is placed on the shelves to dry. If a room with a low humidity is used, the bandages should be left on until the cheese is paraffined. When the room is too dry and the bandages are not left on, the cheese will dry so fast that the rind will crack and make it possible for molds and flies to enter the cheese. If the room is too moist, mold growth may be expected.

As soon as the surface of the cheese feels dry, it is in proper condition to be paraffined. A period of from 3 to 6 days in the drying room is usually sufficient, depending on the size of the cheese and the humidity and temperature of the curing room. If the cheese does not form a dry rind in about 6 days, it should be transferred to a drier room.

During the period in which the cheese is drying and the rind forming, the cheese should be turned and wiped off daily with a clean, dry cloth. After paraffining it is only necessary to turn the cheese often enough to keep it clean and free from mold. The cheese shelves should be washed once a week and placed in the sun to dry thoroughly. This treatment will kill most mold spores that may be present.

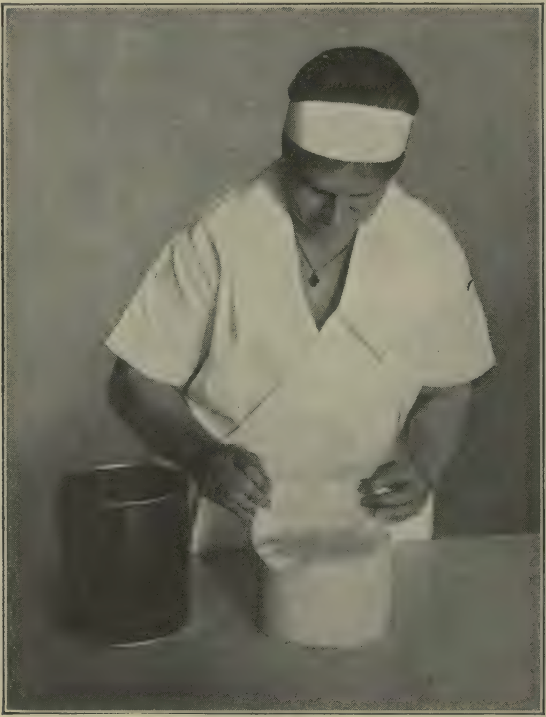

FIGURE 14.—Replacing the cap cloths.

If the cheese is properly made and is properly cared for in the curing room, it will have a firm body and a mild flavor when about 6 weeks old. If a low temperature (below 50° to 60° F.) is provided for curing the cheese, it will cure more slowly, and if a sharp flavor is not objectionable this type of cheese may be held for from 3 to 5 months or longer.

PARAFFINING THE CHEESE

Cheese is paraffined to prevent it from drying too much and also to prevent mold growth. If the surface of the cheese is not dry enough the paraffin will not adhere to it. The paraffin should be heated to between 210° and 220° F. in a receptacle of suitable size into which the cheese can be dipped and held for about 10 seconds. If the paraffin is not hot enough when the cheese is immersed in it, the coat of paraffin will be so thick that it will scale off.

A simple method of dipping the cheese in the paraffin is to immerse one-half or more of the cheese, and then, after allowing a minute or two for the paraffined half to dry, immerse the other half. A 5- or 10-pound cheese can be dipped in this way by holding it in the hand, and the cheese will be completely covered with paraffin.

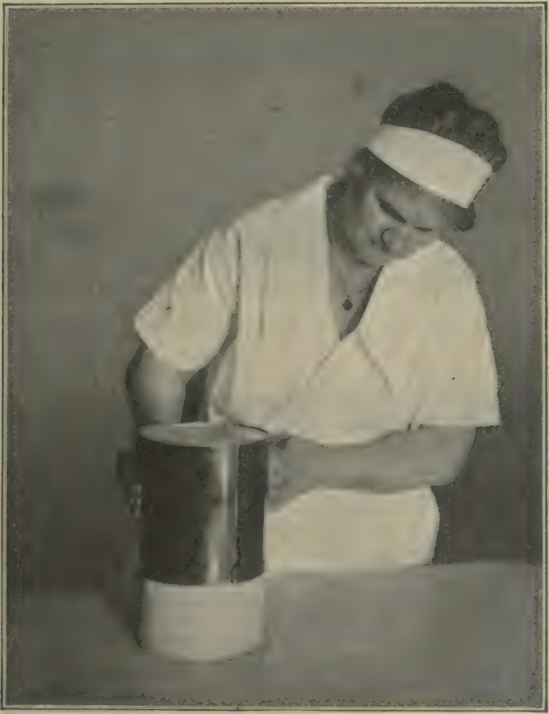

FIGURE 15.—Replacing the hoop on the dressed cheese.

SAVING THE WHEY

One hundred pounds of whey is worth approximately one-fourth as much as a bushel of corn for hog feeding. In other words, if a bushel of corn is worth 40 cents, then 100 pounds of whey is worth 10 cents. Whey can also be fed to chickens. Its high sugar content makes it valuable in preventing and curing coccidiosis in chickens as well as in stimulating growth.

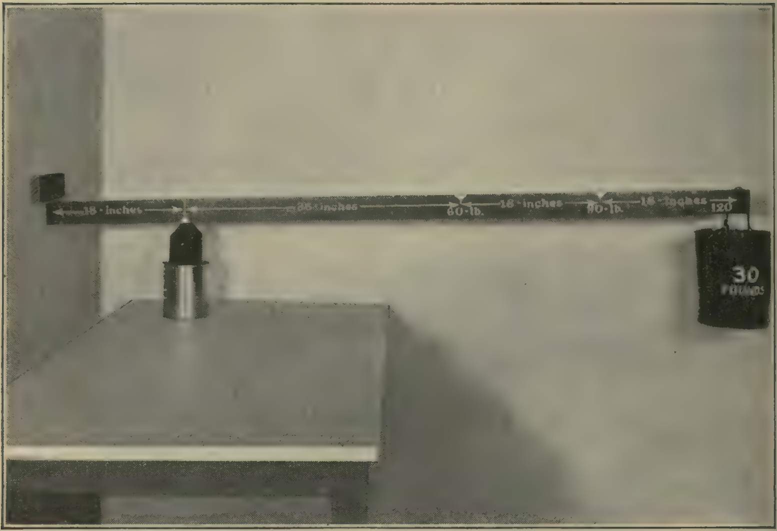

FIGURE 16.—The dressed cheese is pressed for 16 to 24 hours.

FIGURE 17.—The cheese ready for the curing room.

SUMMARY OF POINTS IN PROCEDURE

Use clean, sweet milk for cheesemaking.

Heat milk to 86° F. Use a thermometer to determine the temperature.

Add cheese color if desired, using one-half to 1 teaspoonful to 100 pounds of milk. Do not use butter color.

Add rennet, first diluting it with a pint of cold water. Use 2 to 4 teaspoonfuls to 100 pounds of milk. Stir rennet in thoroughly, then leave milk undisturbed until after it has coagulated, which may take 30 to 35 minutes. Rennet tablets may be used.

Cut the curd when sufficiently firm. Do not crush or break it.

Stir the curd gently for 15 or 20 minutes.

Heat at the rate of 2° in 5 minutes until the temperature reaches 100° to 106° F. Stir while heating.

Allow curd to remain in whey at 100° F. until firm and until enough acid has developed. Do not let curd mat together.

The whey can be removed when the curd is firm enough so that a handful of it pressed together between the hands falls apart readily when the pressure is released.

When the curd has cooled to 90° F. and has a slight acid development indicated by a rubbery texture and a squeaky sound when chewed, add salt at the rate of 7½ tablespoonfuls for 100 pounds of milk.

Have the curd at a temperature of about 85° F.; put it into a hoop, and apply pressure gently.

Dress the cheese, return it to the press, and apply full pressure for 16 to 24 hours.

Place the cheese in a curing room in the coolest available place; a temperature of between 50° and 60° F. is the most desirable.

While the cheese is curing turn it daily until a dry rind forms, then often enough to prevent mold. Paraffin cheese as soon as the surface is dry, which should be within 3 to 6 days, by dipping it in paraffin heated to a temperature of from 210° to 220° F.

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U. S. DEPARTMENT OF AGRICULTURE
FARMERS' BULLETIN No. 1735

PEA DISEASES
AND THEIR CONTROL

PEAS ARE SUBJECT to a number of diseases, several of which may cause serious injury and loss. It is the purpose of this bulletin to describe these diseases briefly, so that they may be identified by the grower, and to give recommendations for preventing and controlling them.

Ascochyta blight is seed-borne. Seed grown in the Northwestern States is practically free from the disease germ and should be obtained for planting if available. Refuse left in the field after the crop is harvested should be plowed under and the peas rotated with other crops.

Bacterial blight is a seed-borne disease, and the same methods of control as for *Ascochyta* blight should be practiced.

The wilt organisms are seed-borne to a slight extent. They live almost indefinitely in the soil, so that crop rotation is of no great value. The only control of the disease consists in the use of resistant varieties, a number of which are now available.

Root rots are caused by a group of several organisms that live a long time in the soil. They cannot be entirely controlled. The losses may be reduced by planting on well-drained soil, by careful preparation of the soil, by maintaining a continuous growth, by the use of the proper fertilizer, and by a judicious crop rotation.

Root knot is caused by a parasitic eelworm that inhabits the sandy soils of the Southern States and California. It causes swellings and galls on the roots of many crops. Some of the cowpeas, grasses, and cereals are resistant and should be used in the rotation. Many weeds are susceptible and should be destroyed by clean cultivation.

Powdery mildew produces a white, talclike powdery growth on the leaves and other parts of the plant. When control measures are necessary, dust with sulphur. The first application should be made when the disease first appears. Several applications may be necessary to hold the disease in check.

Septoria blight, anthracnose, and downy mildew are three diseases that do not occur commonly. They rarely require the application of control measures, and none are recommended. Seed grown in the Northwestern States is more nearly free from seed-borne diseases than that grown in the East and should be used for planting when available.

Washington, D.C. Issued November 1934

PEA DISEASES AND THEIR CONTROL

By L. L. Harter, *senior pathologist*, W. J. Zaumeyer, *associate pathologist*, and B. L. Wade, *associate geneticist, Division of Fruit and Vegetable Crops and Diseases, Bureau of Plant Industry*

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THE PEA INDUSTRY

PEAS are an important food in the diet of a large percentage of the population of the United States. They are grown to some extent in practically every part of the country, either for home use, for market, for canning, or for seed purposes. A much greater number of growers raise peas for home use than for any other purpose. The total acreage so grown is, on the whole, small, since only a small quantity, or enough to supply the family needs, is grown in each garden.

The growers engaged in the commercial pea industry may be divided into four groups: (1) The market gardeners or truck farmers, who grow peas for consumption as a green vegetable; (2) those who grow peas for canning; (3) the seed growers; and (4) farmers who produce dry field peas. The growing of green peas for market is carried on by a large number of farmers along the Atlantic seaboard, the Pacific coast, and to a considerable extent throughout the Central States and in some of the Intermountain States of the West. The culture and shipment of green peas are so widely distributed that peas are now available over much of the country during almost the entire year. The commercial canning of green peas is somewhat localized and represents an important part of the industry in several States, as, for example, Wisconsin, Maryland, and New York. A large number of farmers grow peas for the canners. The seed-growing phase of the industry is highly specialized and is centered chiefly in Washington, Idaho, Montana, and California, and to a less extent in Wisconsin and Michigan. The production of seed is largely in the hands of a comparatively small number of commercial concerns, although a considerable number of farmers are engaged in the growing of the seed for them. Dry field peas are produced in the above-mentioned States and to some extent in Colorado. Many of the field peas are used for splitting for soup, for animal feeding, and as seed for forage, green manure, and cover crops. There is considerable overlapping between seed- and field-pea production, since if a crop grown for seed is not sold for seed purposes it may be sold as dry field peas (fig. 1).

LOSSES FROM DISEASES

The annual losses to the pea crop from diseases can scarcely be estimated (fig. 2). They vary from year to year, depending in many cases on local weather conditions. There may be considerable loss one year and little or none the next. If the soil is wet from excessive rains and the weather is cool, heavy losses may be expected from root rots and from such diseases as the *Ascochyta* blight and the bacterial blight. If the soil is badly infested, total loss may result from disease.

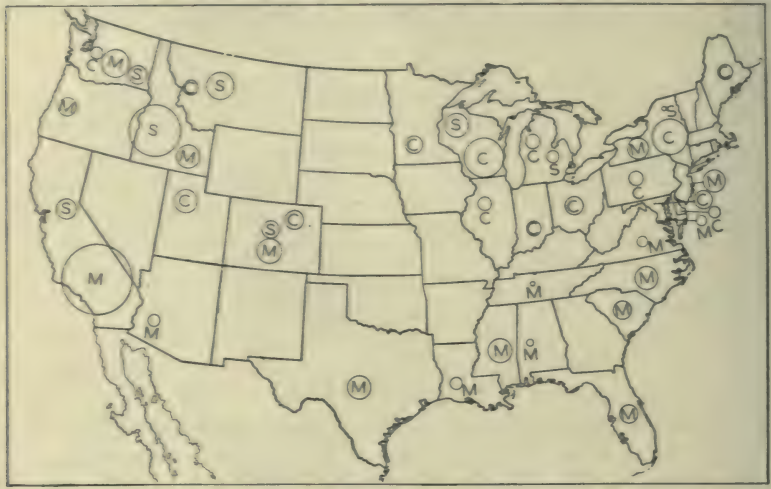

FIGURE 1.—Principal areas of commercial pea production in the United States. *M* indicates peas grown for market; *C*, for canning; and *S*, for seed. The area of the circles roughly indicates the relative size of the industry in each State.

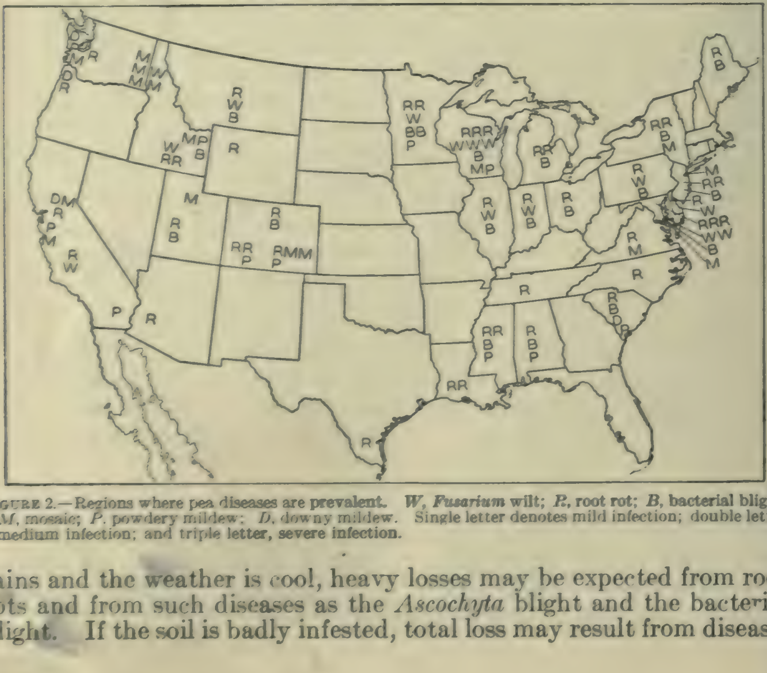

FIGURE 2.—Regions where pea diseases are prevalent. *W*, *Fusarium* wilt; *R*, root rot; *B*, bacterial blight; *M*, mosaic; *P*, powdery mildew; *D*, downy mildew. Single letter denotes mild infection; double letter medium infection; and triple letter, severe infection.

This bulletin contains descriptions of the various pea diseases, information as to their causes, and recommendations for their prevention and control. Unfortunately, in some cases no control measures are known.

HOW THE VARIOUS DISEASES ARE DISSEMINATED

The fungi and bacteria causing diseases of peas may be carried from one place or plant to another by various means, such as insects, infected seed, drainage water, refuse and stable manure, farm animals and implements, and wind.

INSECTS

There is no way to determine to what extent insects carry disease germs from one plant to another, but it may be considerable in some cases. Insects such as plant lice, thrips, and leaf hoppers, are common inhabitants of plants and migrate from one to another with considerable frequency. Wounds made by insects feeding on the plant offer favorable places for infection to take place. Insects visiting the lesions caused by fungi and bacteria may carry the germs on their bodies and deposit them on noninfected plants and perhaps in the wounds made by the insects, and in this way, if conditions are favorable, start new infection centers.

INFECTED SEED

Some of the worst plant diseases are carried by the seed. Since this is particularly true of certain diseases of the pea, it is important that disease-free seed be used whenever possible. In most cases, if clean seed is planted, a crop can be grown without very much loss from those diseases that are commonly seed-borne. On the other hand, if infected seed is sown, heavy losses may be expected if weather conditions are favorable to the development of the disease-producing organisms. Seed grown in the intermountain section of the West and along the Pacific coast is more likely to be free from seed-borne diseases than that grown in the regions east of the Rocky Mountains. For that reason, it is advisable to use seed grown in that section of the West whenever possible.

In order to economize in the purchase of seed, farmers sometimes save seed from their own crop. This is a practice not generally recommended and is probably not an economical one. Seed growing is an industry requiring particular knowledge of the type and quality of the varieties grown and special care in maintaining the purity and trueness to type of the stock. The seed-growing companies employ individuals with expert knowledge of these matters whose responsibility is to improve and to maintain the high quality of the seed stock. They are therefore better equipped to supply high-class disease-free seed than anyone unskilled in the seed business. The purchase of disease-free seed from reputable firms is to be recommended.

DRAINAGE WATER

Surface drainage water running from one field to another may be the means of spreading germs, and in some cases explains the outbreak of a disease in fields where the crop has never been grown before. If the crop is planted on high ground, the germs left in the soil may be carried by the water to low-lying fields. With the hope of avoiding disease by crop rotation, a low-lying field may be selected for the new crop only to find the disease on it as bad as on the abandoned one.

REFUSE AND STABLE MANURE

The pea vines are disposed of in different ways after the peas are shelled, depending to a considerable extent on local conditions and farm needs. In some localities the straw is returned to the soil after the peas are hulled. In other localities it is stacked and used as feed and bedding for livestock, while in still others, the vines are made into silage to be later fed to livestock. If the vines are diseased and are returned directly to the land, the causal organisms serve as a probable source of infection to the succeeding crop of peas. Just what happens to the disease germs on vines put into the silo is not definitely known. The probabilities are that they are destroyed, and, if such is the case, the vines made into silage will not be a source of infection to succeeding crops. On the other hand, returning those vines to the field either in the form of hulled vines or mixed with stable manure would be a means of disseminating the germs to all parts of the farm where this mixture was scattered.

In irrigated regions of the West where peas are grown on a commercial scale, the threshed vines are sometimes used to dam irrigation ditches in order to divert the flow of water into other ditches or to the fields. This is one of the worst possible practices, since if there are any disease-producing organisms on the vines, they will be carried by the water to all parts of the fields.

FARM ANIMALS AND IMPLEMENTS

Farm animals are potential agencies in the distribution of disease germs from one field to another. A certain amount of movement of livestock from one field to another may be unavoidable in the course of farm operations, but as little of it should be allowed as possible when there has been serious loss from diseases. Horses, cattle, or other livestock grazing in a diseased field or feeding on the refuse after the crop is harvested are likely to scatter the disease organisms. Farm implements may likewise be a means of transporting the germs from one place to another, although no great distribution need be expected from that means. Reasonable care should be taken so that infested soil will not be transported from one field to another by roaming animals or by farm machinery. The threshing machine, when used to thresh the crops of different farmers, may carry disease-producing germs from one farm to another. A thorough cleaning of the thresher before it is moved to a new field will eliminate much of this danger.

WIND

The wind may be an important factor in the dissemination of certain pea diseases. In localities where strong winds are prevalent, dry weather common, and the soil light, the disease spores may be carried long distances. The refuse from a previous diseased crop may also be blown considerable distances when strong winds occur.

FARM PRACTICES IN RELATION TO DISEASE CONTROL

Several methods whereby the various diseases of peas may be disseminated from one field to another or from one locality to another have been mentioned. It should be the purpose of the grower to prevent as much as possible the distribution of destructive diseases on his farm by taking several precautionary measures, the more important of which are discussed in the following paragraphs.

DISINFECTION OF SEED

Inasmuch as some of the worst plant diseases are seed-borne, disinfection of the seed is often of considerable value. However, it destroys only the germs on the surface; those beneath the seed coat cannot be reached without injuring the seed itself. Disinfection of pea seed is of questionable value, but it will do no harm and might be a safe precaution. Experimental data have indicated that treatment of the seed with some of the phenol mercury compounds increases the stand under some conditions, probably because of the protection against decay by soil-borne organisms and the destruction of the disease germs on the surface of the seed. Until more is known about pea-seed treatment, the practice is not generally recommended.

CROP ROTATION

Crop rotation is a good practice even if it is not necessary as a disease-control measure. The germs of several of the pea diseases live in the soil for 2 or 3 years on the debris of previous crops, and others persist almost indefinitely. If peas are repeatedly cropped on the same soil, the disease germs continue to multiply year after year. The lack of information as to the length of time required to starve out all the different organisms attacking peas makes it impossible to make specific recommendations. However, a rotation including peas not oftener than once in 3 years should be practiced. Where farm operations and practices will permit, a longer rotation is desirable. The life of some of the disease germs is shortened if they are buried deep in the soil. In view of that fact, the refuse remaining on the field and the vines returned to it after threshing or hulling should be plowed under as soon after harvest as possible. The use of resistant varieties is about the only way to control those diseases caused by organisms that persist almost indefinitely in the soil and are slightly or not at all influenced by crop rotation and deep plowing. No vetch should be grown in a pea rotation, since the two crops are attacked by some of the same diseases.

DISEASES

ASCOCHYTA BLIGHT

DESCRIPTION

Ascochyta blight is characterized in part by the formation of black to purplish streaks on the stem. The lesions are more conspicuous at the nodes, and enlarge into brown or purplish irregularly shaped areas scattered indiscriminately from the roots to 10 inches or more up the stem.

The leaves may show characteristic symptoms (fig. 3) of the disease in various ways. The spots may be very small, purplish, and very irregular in shape and size, or they may be fairly large and more or less circular. The size and number of the spots and the amount of damage caused depend somewhat on the age of the plants and weather conditions. Under favorable conditions the entire leaf of very susceptible varieties may be so badly injured that it shrivels and dries up. Concentric circles sometimes form in the spots on the leaves.

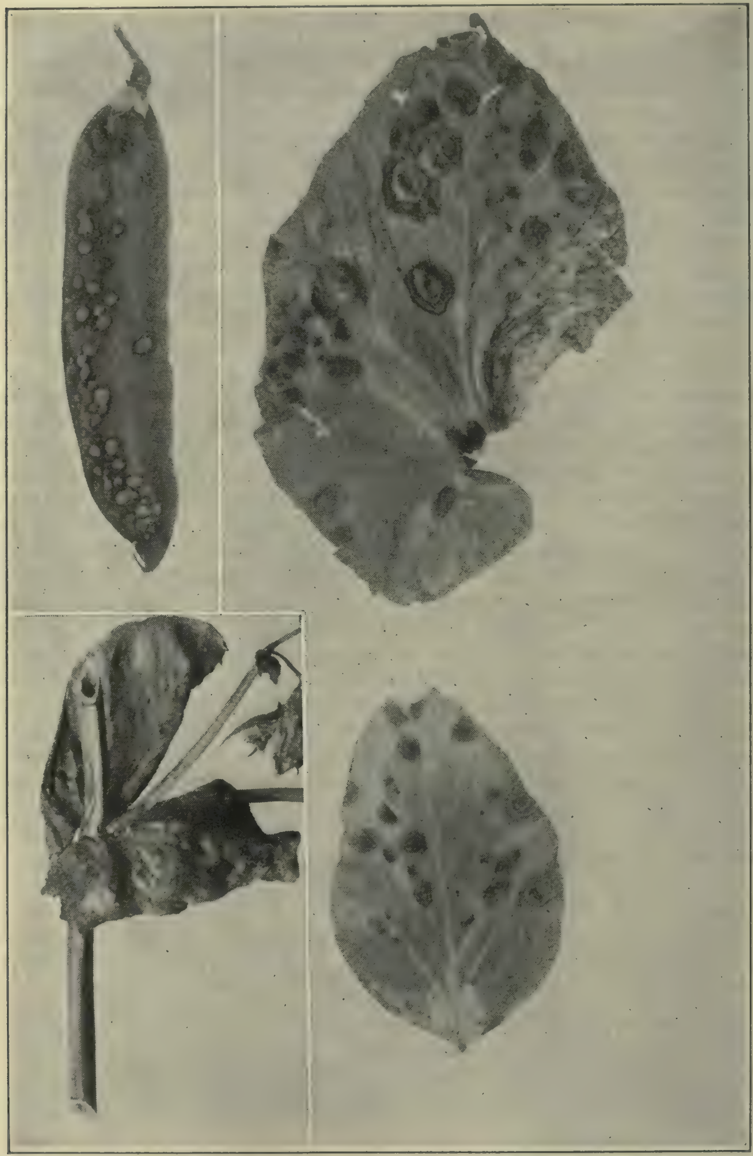

FIGURE 3.—*Ascochyta* blight on the pods, stems, and leaves. Small dark fruiting bodies about the size of a pin point occur in the more or less circular spots. The spores are enclosed in these receptacles, and, on escaping, may fall on other plants and serve as sources of new infections.

The symptoms on the pods (fig. 3) are similar to those on the leaves, except that on the pods the spots are sunken and there are no concentric rings. The causal organism frequently grows through the pods and penetrates the seeds which serve as sources of infection if such seeds are used to plant the next year's crop. A few small, black or almost black, slightly raised, pimplelike protuberances, about the size of a pin point, may be found scattered in the lesions of the stems, leaves, and pods. The spores or seed bodies of the causal fungus are produced in these little pimples.

CAUSE

The *Ascochyta* blight is caused by any of three different parasites—*Ascochyta pisi* Lib., *Mycosphaerella pinodes* (Berk. and Blox.) Stone, and *Ascochyta pinodella* Jones. Although the symptoms caused by the three fungi may differ somewhat, they have so many characteristics in common that it seems desirable to treat the diseases as one rather than to differentiate them by fine points of distinction. *Ascochyta* blight may occur in all States east of the Mississippi River, but it is rarely, if ever, found in the semiarid seed-producing regions of the Northwest. It may cause heavy losses during seasons of abundant rainfall. The causal organisms are carried by the seed and infect the seedling when it is emerging. Rains following germination splash the spores to surrounding plants, and eventually all the plants in a field may become infected.

CONTROL

The fungus causing *Ascochyta* blight is seed-borne and may also live from one season to the next on the refuse in the field. New infections may start from the use of infected seed and from the refuse left in the field. These facts suggest the importance of using only clean seed and of destroying the refuse in the field. It is not possible to destroy all the refuse in the field, but considerable benefit may be obtained by plowing it under deep as soon as the crop is harvested. Clean or practically disease-free seed is grown in the semiarid regions of the Northwest and should be purchased and used whenever possible. Probably all stocks of seed grown east of the Mississippi River carry the fungus; therefore, it is recommended that western-grown seed be used. At least a 3-year crop rotation should be practiced, and diseased pea vines should not be scattered on land to be used for the next year's crop.

Seed treatment is not recommended. No varieties of peas have been found that are entirely immune to *Ascochyta* blight, although some are less susceptible than others and may be tried if they are suitable to local needs. Some of the less-susceptible varieties are: Short Admiral, Badger Special, Champion of England, Horal, Horsford, Perfection, and Advancer. Complete control of *Ascochyta* blight is probably not possible until definitely resistant varieties have been developed by breeding and selection.

BACTERIAL BLIGHT

DESCRIPTION

The bacterial blight of peas is found on all parts of the plant above the ground. If the infection starts from the seed or if the plants are 3 or more inches high, the vine may be killed without producing a crop. Infection established later may reduce the yield considerably, the extent of the injury depending largely on weather conditions, Bacterial blight causes water-soaked lesions on the pods (fig. 4, *A*).

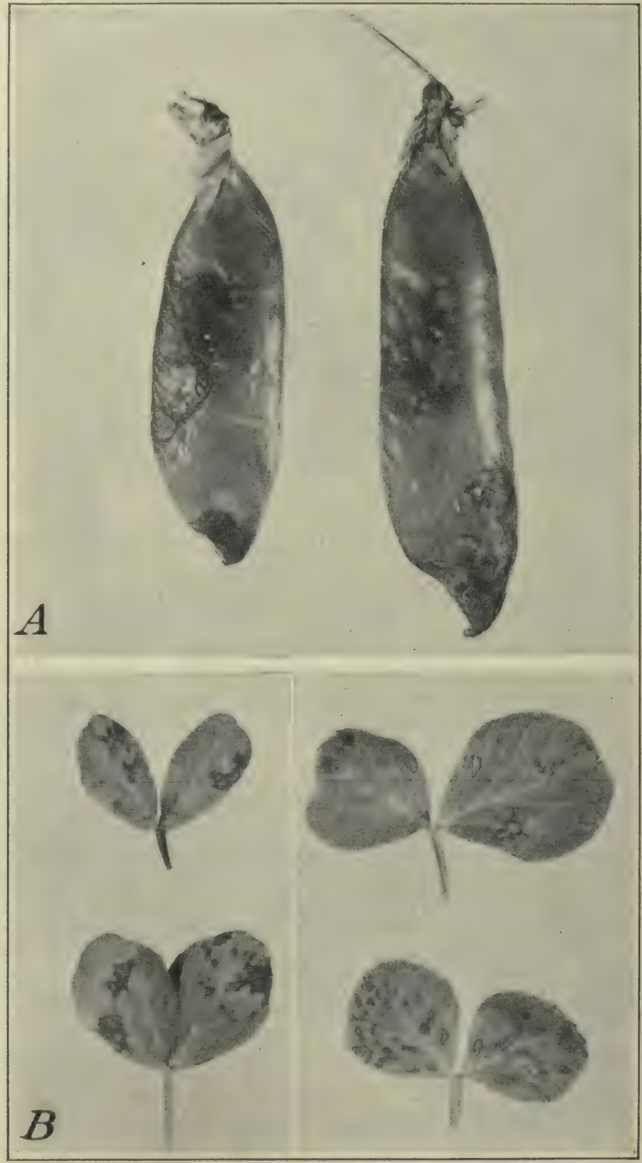

FIGURE 4.—*A*, Bacterial blight on the pods, showing water-soaked, irregularly shaped, slightly sunken spots. The seed may be invaded by the parasite and serve as a source of infection for the new crop. Such seed should not be planted. *B*, Bacterial blight on the leaves. These spots start as small water-soaked areas which gradually kill part of the leaf. Sometimes the injury is so extensive that the plant dies.

stems, leaves (fig. 4, *B*), and stipules. These lesions enlarge under humid conditions, sometimes forming spots of considerable size. A white to cream-colored slimy ooze may also collect on the surface of the lesions. On the other hand, if the weather turns dry, the infection may dry up. The infected tissue of the leaves and stipules eventually turns brown and papery in texture. Extensive infection of the pods reduces considerably their market value because of their unsightly appearance. There is the danger also that the germs will grow through the pods and infect the seed, which would be a source of infection if the seed was used to plant a new crop.

Bacterial blight has been reported from many States from the Pacific to the Atlantic coasts. The extent of the loss from the disease is not known, but it has been estimated to amount to as much as 25 to 30 percent or more in some fields. It is most severe under conditions of high humidity.

The organism causing bacterial blight of peas is said to produce a similar disease of cowpeas, sweet peas, everlasting peas, and the hyacinth-bean.

CAUSE

Bacterial blight is caused by a parasite (*Bacterium pisi* Sack.) that lives over the winter in the seed but probably not on the refuse left in the field from harvesting. If the germs do not survive the winters in the field, the seed is practically the only source of infection.

CONTROL

No effective control measures are known. Clean seed, if available, offers the best possibility of avoiding infection. Although the disease has been reported from several Western States, there are a few localities in which peas are grown under dry-land conditions where the disease does not occur. A large quantity of pea seed is now being grown under dry-land conditions in what is known as the Palouse area, comprising parts of eastern Washington and northern Idaho. The grower of peas for canning and market-garden purposes should request the seedsmen to supply seed free from the bacterial blight. At any rate, there are good reasons to believe that seed grown in the Western States will be safer to plant and freer from infection than seed grown in the Eastern States. Seedsmen who grow in areas where bacterial blight occurs might profitably alternate infected basic seed stock each year between the dry land and irrigated land, in order to free the seed of the causal organisms.

Seed treatment is not generally recommended, as it is of value only in disinfecting the surface. No permanent control under all conditions can be expected until varieties resistant to the disease have been developed by breeding and selection.

FUSARIUM WILT

DESCRIPTION

When *Fusarium* wilt first makes its appearance in a field, only a few plants show any signs of disease. If susceptible varieties are planted several years in succession on the same field, the infested areas (fig. 5) gradually enlarge and become more numerous and eventually merge with others. Finally, all the soil in the field may be infested.

Attention is first attracted to the wilt disease by the yellowing of the lower leaves and the stunted growth of the plant. A more careful examination shows a definite downward curling of the margins of the leaves (fig. 6). If infection occurs when the plants are fairly small, they may die without producing any peas; on the other hand, if the plants are older when infected, a few pods, poorly filled, may develop. At or near the soil level, the vine is sometimes slightly swollen. Infection takes place from the soil, through the roots, and the causal organism follows the water-conducting canals up the stem, often well into the upper branches, thus hindering the passage of water to the stem and leaves. If the lower part of the stem or the main root is cut open by a sharp knife, the presence of the organism is often indicated by the lemon discoloration it causes to the canals. In some cases, however, no discoloration is produced even though the wilt organism is present. These symptoms must not be confused with the much brighter brick-red discoloration of the water canals caused by a different organism. If wilt-infected plants are pulled several days after injury is apparent, root-rot germs, or other disease-producing germs in the soil, may have damaged the roots to such an extent that it is almost impossible to determine with certainty what organism was responsible for the injury.

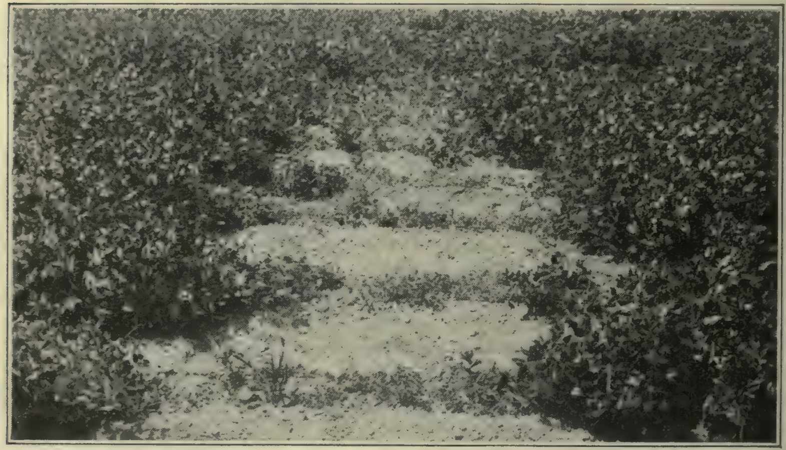

FIGURE 5.—*Fusarium* wilt. A portion of a field showing a typical *Fusarium*-wilt infested area.

CAUSE

Fusarium wilt of peas is caused by a fungous parasite (*Fusarium orthoceras* Appel. and Wr. var. *pisi* Linford) and is very similar to organisms causing wilt in a number of other cultivated plants, among which may be mentioned the tomato, sweetpotato, cotton, cowpea, watermelon, and cabbage.

CONTROL

There is no cure for the pea wilt. As the parasite will live indefinitely in the soil, there is no chance to starve it out by rotation with other crops. Its control can be accomplished only by the growing of resistant varieties. During recent years the canners and market gardeners, especially the former, have been demanding strains that

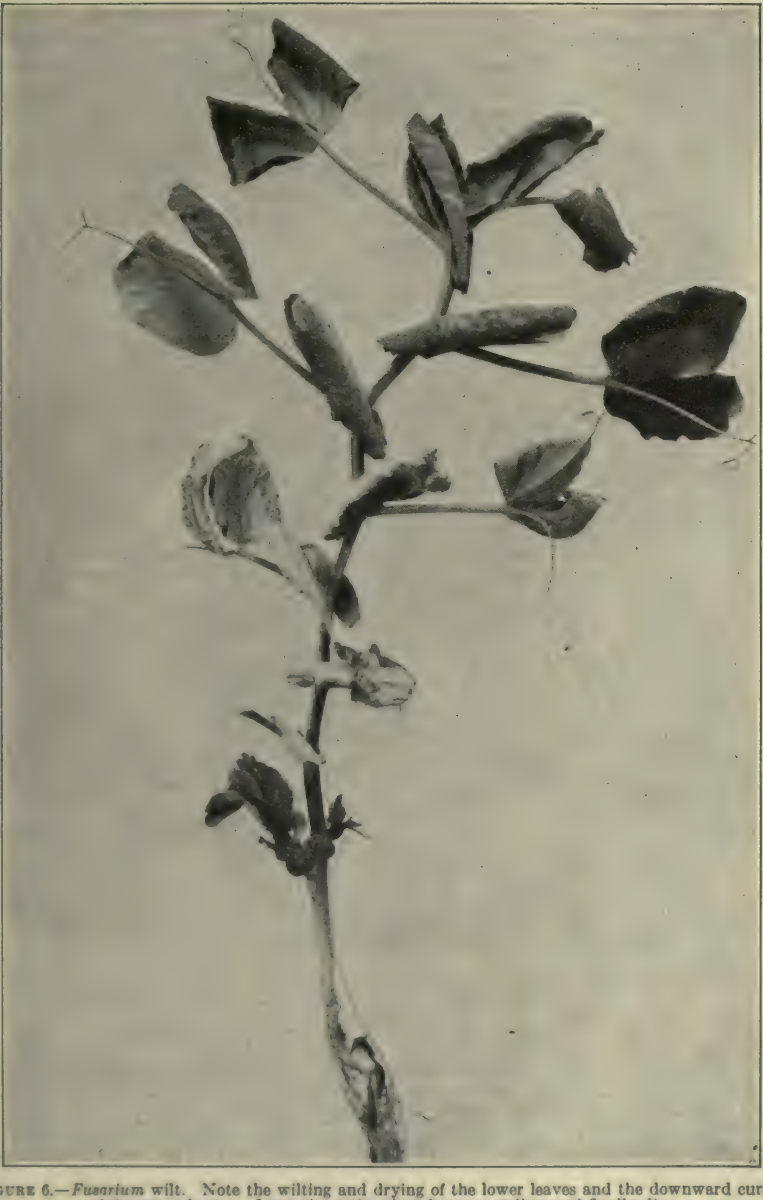

FIGURE 6.—*Fusarium* wilt. Note the wilting and drying of the lower leaves and the downward curling of the upper leaves. Later the entire plant becomes yellow and finally dies.

would produce a crop on soil infested with the wilt organism. In response to this demand, some of the State experiment stations and the private seed companies began an intensive study of the problem and of the needs of the canners and market producers. It was found that in many cases a certain percentage of the plants on badly infested soils resisted the disease. By collecting seed from such plants and growing it on infested soil to eliminate the susceptible plants, it has been possible in the course of a few years to develop strains entirely resistant. Similar results have been accomplished by crossing a susceptible variety with a resistant one and selecting the resistant plants of the desired type from the progeny. By growing the seed each year on infested soil, it was possible to select the required type carrying disease resistance. A number of resistant strains, especially of the canning types, are now on the market. The indications are that resistant strains of the choice market-garden varieties will be available within the next few years.

TABLE 1.—*Some of the common varieties of peas grouped according to commercial use and season, and graded with respect to their relative resistance to Fusarium wilt*

Commercial use, season, and variety	Degree of resistance	Commercial use, season, and variety	Degree of resistance
Market-garden varieties:		Canning varieties:	
Early:		Early:	
Alaska	[1] 0–100	Alaska	0–100
American Wonder	0	Early Canner	0
Bliss Everbearing	100	Peerless	100
Claudit	0	Surprise	0
Duke Delight	0	Wisconsin Early Sweet	100
Extra Early	0–100	Midseason:	
First and Best	0–100	Abundance	0–100
Gradus	0–50	Advancer (Perfection)	0
Hundredfold	0	Ashford	0
Little Gem	0	Bruce	100
Little Marvel	0	Badger	0
Peter Pan	0	Canners Gem	0
Pioneer	0	Green Admiral	100
Premium Gem	0	Green Giant	100
Thomas Laxton	0	Horal	100
World Record	0–100	Horsford	0
Medium early:		Perfection (Advancer)	0
Laxtonian (Blue Bantam)	0	Prince of Wales	100
Laxton Progress	0	Resistant Perfection	100
Nott Excelsior	0	Rogers K	100
Sutton Excelsior	0–100	Senator	100
Midseason:		Short Admiral	0
Alderman	100	Yellow Admiral	100
Associated 40 or Dwarf Alderman	100	Field varieties:	
Daisy or Dwarf Telephone	0–100	Early:	
Morse No. 200	0	Alaska	0–100
Onward	0–100	Extra Early	0–100
Rogers No. 93 or Icer	100	First and Best	0–100
Stratagem (Potlatch)	0–100	Midseason:	
Stridah	100	Austrian Winter	0–10
Tall Telephone	90–100	Bluebell (Blue Prussian)	100
		Capucijner	25–100
		Harrison Glory	100
		Maple	0
		White Australian	100
		White Canadian	0–100

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[1] The figures 0–100, for example, indicate that some strains of the variety are 100 percent susceptible; others are 100 percent resistant, and still others are intermediate between 0 and 100.

Table 1 contains a list of a number of common varieties of peas and shows whether or not they are resistant, partially resistant, or susceptible to the wilt disease. It is advisable to select some of these resistant varieties for planting on soils that are known to be infested with the wilt organism. Attention should be called to the fact that there are possibly available some resistant strains in practically all of the varieties marked 0–100 percent in table 1, if the grower insists on being supplied with such stock. Investigations have shown that strains of peas that are resistant to *Fusarium* wilt in one locality are resistant to the same organism in any other infested locality, no matter how far removed. In the case of canning peas, it is not advisable to sow partially resistant peas on infested soil. Not all infected plants are killed before they produce seed. However, infected plants that survive usually mature earlier than noninfected plants and pass the canning stage before the bulk of the crop is ready to harvest. Many of these prematurely ripened peas reach the can and reduce the quality of the pack.

NEAR WILT

DESCRIPTION

There has come to notice in recent years a disease of peas called "near wilt." It somewhat resembles the *Fusarium* wilt and sometimes might be confused with it. Not much is known about the disease, but attention is called to it so that losses caused by it will not be attributed to the *Fusarium* wilt. The causal fungus enters the water canals of the taproot and stem, just as does the wilt fungus, and may cause the wilting and death of the plant. The near wilt may attack the plant at a later stage of growth, sometimes after the crop is nearly mature. For this reason the loss from near wilt is much less than that from wilt which usually enters the stems of very small plants and kills them while they are fairly young. The near wilt might be overlooked entirely, and the sickly appearance of the plants attributed to root rots, lack of soil fertility, or other causes. Near wilt differs from root rot and may be distinguished from it in at least two characteristics. Plants affected with root rot usually pull from the soil much easier than near-wilt or wilt plants. Near-wilt plants may not show any signs of decay of the root. If the taproot is split open with a sharp knife and the central core is colored a brick red, the presence of the near-wilt organism is to be suspected. Attention should be called to the fact that if wilt-resistant strains of peas should fail to yield a crop on certain fields, it is not necessarily because they are not wilt resistant, but may be because of the presence of the near-wilt or even root-rot organisms. Varieties of peas resistant to wilt are not necessarily, and probably are not, resistant to near wilt. There are, however, some indications that varieties may differ in their susceptibility to near wilt.

ROOT ROTS

DESCRIPTION

Root rots are caused by several different parasites that produce symptoms so much alike that it is not always easy by a casual examination to distinguish them. Inasmuch as the known control measures apply about equally well to all root rots, any attempt to separate them by descriptions that, in part at least, may apply to all the root rots would only tend to confuse the reader.

Root rots, as the name indicates, occur on the roots or on all the underground parts of the plants and sometimes a short distance above the surface of the soil and are the cause of much loss. Most of the lesions are grayish brown or almost black, but occasionally some are reddish and form definite streaks on the taproot or on the stem near the soil line. Root decay often begins at the tips of the small feeding roots and progresses gradually upward to the main root. In other cases, all the roots are destroyed, leaving nothing, or only shreds, below the attachment of the seed (fig. 7). Sometimes, however, the main root is the first to be affected.

In the root rot caused by the parasite *Aphanomyces euteiches* Drechs. the initial infection may take place either through the small feeding roots or directly on the taproot. The final result is that the surface becomes more or less soft and slimy, and dark gray or brownish black in color. The slimy condition of the surface is influenced somewhat by the amount of moisture in the soil. In typical examples of root rot caused by this parasite, the outer portion of the taproot can be slipped readily from the central cylinder, which may often become somewhat water-soaked and soft. The decay may extend a short distance above the surface of the soil.

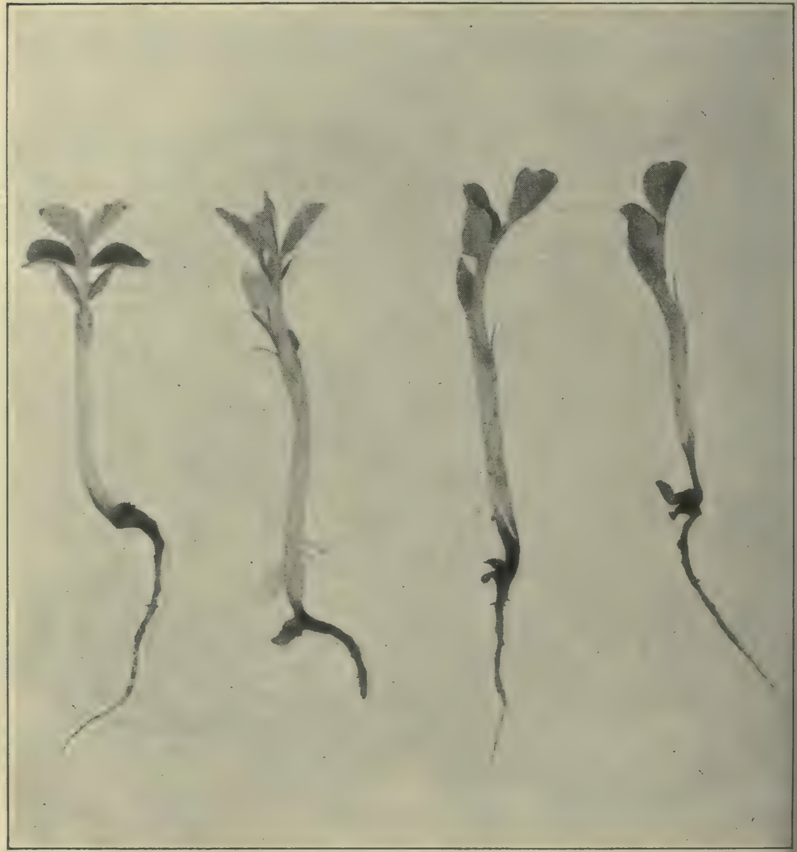

FIGURE 7.—Root rot. The feeding roots below the attachment of the seed are sometimes entirely rotted away. Similar injuries may be caused by several different organisms.

The root rot described above should not be confused with another very wide-spread root rot caused by the parasite *Fusarium martii* var. *pisi.* This fungus usually attacks the lower part of the stem in the region of the attachment of the seed (fig. 8), and grows in both directions but more conspicuously up the stem, turning the infected region a dark brown to a brick red. The same parasite may be found

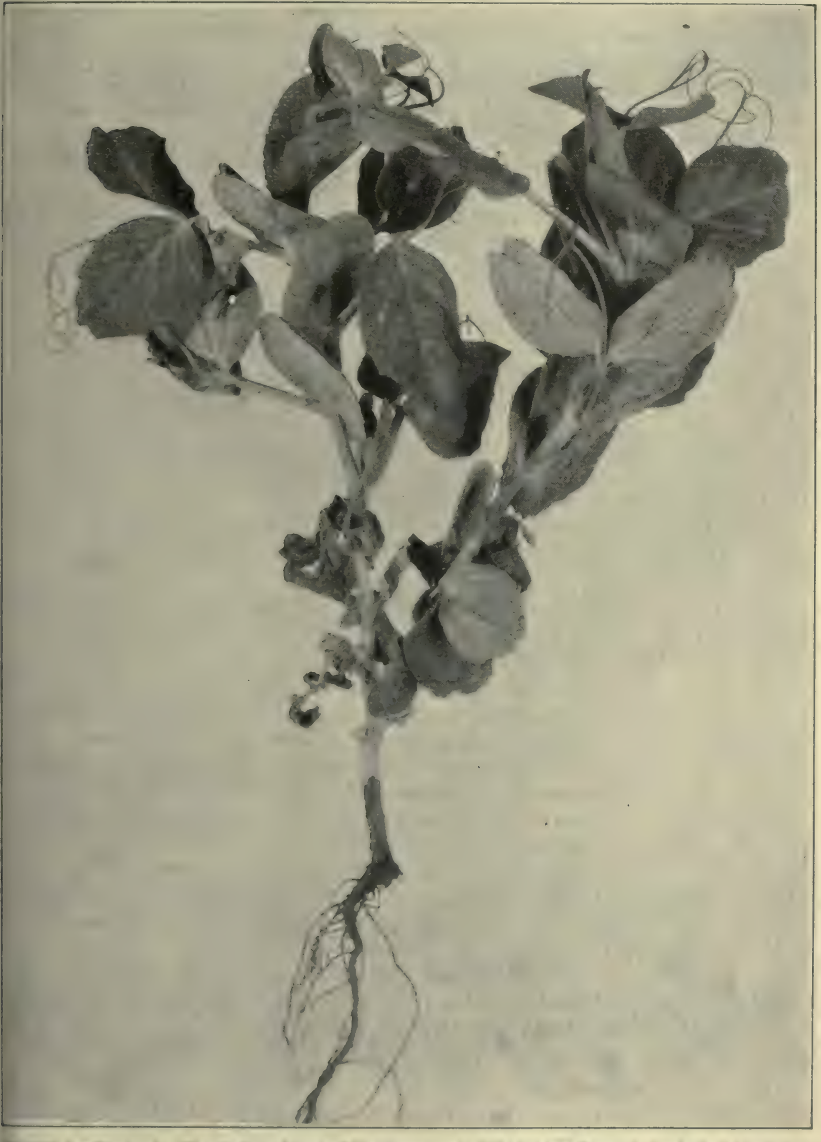

FIGURE 8.—Root rot. The darkened area of the upper part of the root and stem is typical of a root rot that causes decay of the stem both above and below the attachment of the seed. In later stages the plant may turn yellow and eventually die.

on the feeding roots, but it is found less commonly there than on the main root. This root rot may be identified with more certainty by the deep-red discoloration it causes to the central cylinder. By splitting open the stem at, or just above, the place where the seed is attached, the red coloring caused by the presence of the fungus may be seen to extend a little distance upward. Symptoms of other root rots might be described, but it would not be possible to give sufficient detail so that they could be distinguished from root troubles caused by other parasites. In advanced stages, the symptoms for all the troubles are very much alike. In fact, the root troubles of a single plant are not always caused by one parasite only. Several may be damaging the roots at the same time.

No particular skill is required to recognize root rot. Any observant farmer can recognize root trouble if he will take the pains to examine the roots. It makes very little difference what organism or group of organisms cause them; in fact, those who have been long engaged in the study of root rots are frequently unable to identify the different ones without a laboratory study. If the plants in the field are stunted, the leaves pale yellow, or exhibit an unhealthy appearance in other ways, it is a good plan to dig up some of the plants, carefully wash off the soil, and examine the roots for decay. They may be found wherever peas are grown, but the losses may sometimes be very small. Taking the country as a whole, it is believed that more loss is caused by root rots than by any other disease, and possibly more than by all other diseases combined. Root rots and wilt frequently occur together in the same fields; in that case it is difficult to determine which causes the greater loss.

Root rots may begin when the plant is in the seedling stage or, in fact, before it comes through the ground. Death of the plant soon follows such early infections.

CAUSE

Several organisms are known to cause root rots, and it is not unlikely that others that are not suspected, or that are little known, may be as responsible as those mentioned below. Those fungi generally associated with root decay are known by the following names: *Fusarium martii* App. and Woll. var. *pisi* Jones, *Aphanomyces euteiches* Drechs., *Corticium vagum* Berk and Curt., *Pythium ultimum* Trow., *Ascochyta pinodella* L. K. Jones, *Mycosphaerella pinodes* Berk. and Blox., *Sclerotinia sclerotiorum* (Lib.) Mass., *Thielavia basicola* (Berk. and Br.) Zopf, and *Sclerotium rolfsii* Sacc. The last-named organism requires especial mention, because it is restricted mostly to the Southern States. Several of these organisms cause root rots of crops other than peas, and probably all of them can live indefinitely in the soil independently of any of our cultivated crops.

CONTROL

The root rots of peas, like those of many other crops, are hard to control. As they are caused by organisms that live indefinitely in the soil, there is no practical way to eradicate them. Crop rotation is recommended as a good practice, but it is of no particular value in controlling pea diseases except in the case of those organisms that attack only peas. Most of the fungi are about as parasitic on the other crops that might be grown in the rotation as on peas.

Root rots are usually more severe during seasons of heavy rainfall than during dry years, and on low-lying fields that are poorly drained than on well-drained fields. Excessive soil moisture, regardless of the location of the field, favors the root-rot diseases. Where root rots have been troublesome, it is advisable to select well-drained fields and to prepare the soil thoroughly before planting. Plants that start growth poorly, as they do on impoverished soils, are much more subject to attack of root rots than plants on rich soils where a good vigorous growth is maintained from the very beginning. This naturally suggests that a fertilizer of the proper proportion of ingredients should be added to the soil where needed. The grower should provide conditions that will start the plants off well, and should keep them growing vigorously by selecting well-drained soils, by careful preparation of the soil, and by the application of the proper amount of fertilizer. At least a fair crop often can be grown in spite of root rots.

ROOT KNOT

DESCRIPTION

Root knot, largely confined to the light sandy soils of the South and to similar regions in California, is characterized by enlarged, irregularly shaped, deformed, fleshy galls (fig. 9) distributed on the root system. If the galls are broken open, pearl-white bodies about the size of a pinhead may often be seen. These are the female worms that cause the galls.

The root-knot galls may sometimes be confused with the nodules that normally develop on the roots of garden and field peas, beans, and other legumes. A careful comparison shows the two to be quite different. The nodules are usually smaller than the root-knot galls, more nearly round, and are attached somewhat loosely to the roots, whereas the root-knot galls are enlargements of the roots themselves. The bacteria that form the nodules change the nitrogen of the air into forms that are of some benefit to the plant and that are later changed into nitrates in the soil and thus become available to subsequent crops. Plants bearing nodules generally grow well and look healthy, while those with root knot are usually stunted, yellow, sickly looking, and may even be killed by the disease.

CAUSE

Root knot is caused by a parasitic eelworm, or nematode (*Heterodera marioni* (Cornu) Goodey) so small as to be almost invisible to the naked eye. It enters the roots and causes them to form irregular swellings or galls characteristic of the disease. It retards the growth, reduces the yield, and often kills the plants. To a considerable extent, these galls cut off the transport of food material from the roots to the rest of the plant. These little eelworms travel very slowly in the soil, probably not more than 1 to 2 yards in a year and they overwinter in the soil.

CONTROL

The eelworms, or nemas as they are generally called, are parasitic on a large number of cultivated plants and on many weeds. However, a number of crops are practically immune to their attack. Among the latter may be mentioned the Iron, Brabham, and Victor cowpeas; the Laredo soybean, velvetbeans, corn, barley, rye, redtop, sorghum, timothy, wheat, and winter oats.

The most satisfactory method of controlling the disease is to practice rotation with immune crops for 3 or more years, in order to starve out the nemas. Clean cultivation should be practiced to prevent the growth of susceptible weeds on which the nemas could feed. The nemas may be transported from one field to another or over long distances in the tubers, bulbs, or roots of growing plants, by implements

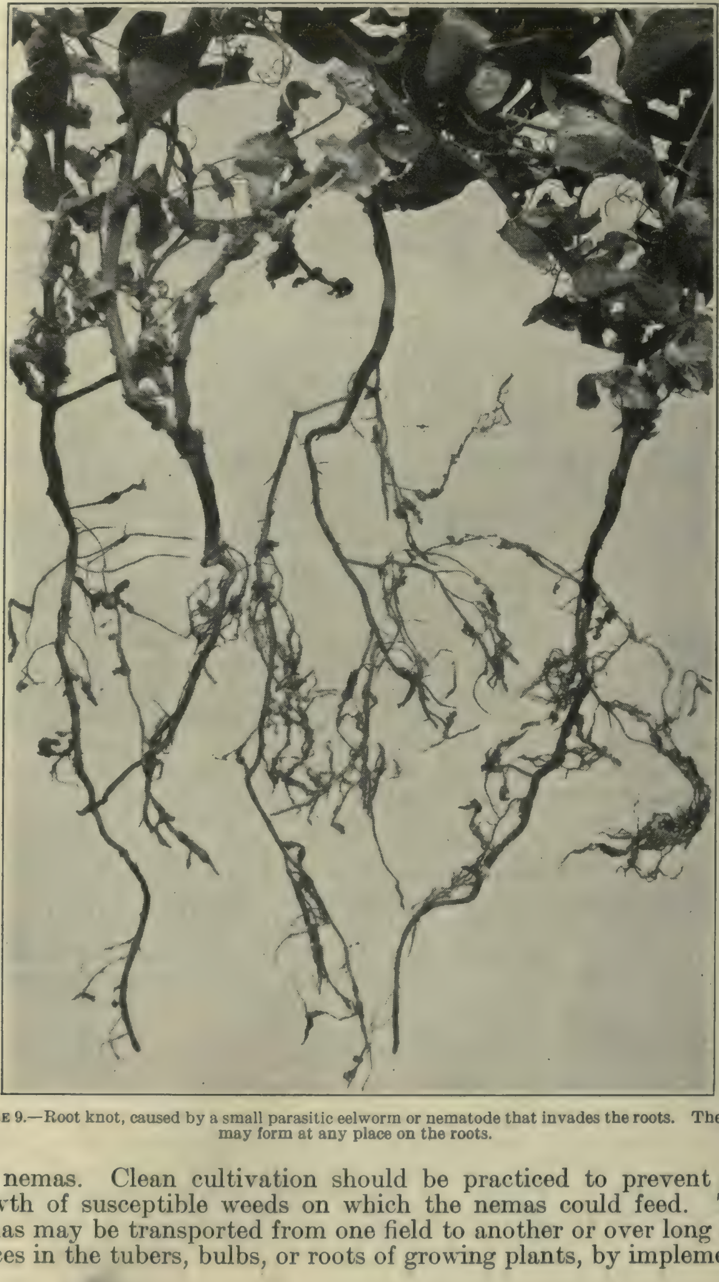

FIGURE 9.—Root knot, caused by a small parasitic eelworm or nematode that invades the roots. The galls may form at any place on the roots.

and drainage water, by farm animals allowed to roam from one field to another, and probably by other means. Distribution of the nemas by any of these means should be prevented as far as possible.

SEPTORIA BLIGHT

Septoria blight, caused by a fungous parasite (*Septoria pisi* West.), is one of the less important diseases of peas, and for that reason a somewhat brief discussion will suffice. It occurs mostly in the Northern States and develops best under cool, wet weather conditions. The *Septoria* blight is sometimes confused with the *Ascochyta* blight, but when the two diseases are carefully compared they may be easily distinguished. The spots caused by *Septoria* are somewhat indistinct, while those caused by *Ascochyta* are distinct. The *Ascochyta* blight is in part characterized by lesions with ashen-gray centers. With the *Septoria* fungus, however, the infection begins at the edge of the leaf, causing yellowish indefinite areas which gradually darken and enlarge until the entire leaflet is invaded (fig. 10). From the leaflets, the causal fungus spreads to the nodes, which are likewise yellowed and often shrunken. In the lesions, on the leaves, and especially on the nodes and lower part of the stem, pycnidia, or spore receptacles, more or less indefinitely arranged, are developed. Numerous spores are formed in the pycnidia. The spores emerge from them and are carried by the wind, on the bodies of insects, or by other agents to other plants, where a new infection takes place. By these means, an entire field may become infected within the period of a couple of weeks. If infection takes place when the plants are young, that is 3 to 8 inches high, their death is likely to result before a crop is produced. If, on the other hand, no infection occurs until the plants are nearly mature, a partial crop, at least, can be expected.

Septoria blight occurs in epidemic form with such infrequency that no control measures have been worked out, and only occasionally is there any need to apply them. Until more is known about this disease, little can be offered in the way of control. The methods suggested for the control of *Ascochyta* blight would probably be equally effective in reducing losses from *Septoria*.

POWDERY MILDEW

Powdery mildew of peas is caused by a fungous parasite (*Erysiphe polygoni* DC.). This same fungus occurs on beans and on a number of related legumes. The organism causing the powdery mildew of peas is probably as widely distributed as the crop. Like the powdery mildews of some of the other crops, it develops most abundantly under cool conditions, and consequently it is more prevalent on fall crops or on crops that are matured in the late summer, and where the nights are cool. It is characterized by the formation of a white powdery dustlike coating on the surface of the leaves and less frequently on the petioles of the leaves, stems, and pods. The leaves are yellowed, dwarfed, and sometimes considerably malformed. Only in extreme cases, however, are the vines killed. In severe cases of the disease, the powdery-mildew fungus causes small brown spots (fig. 11) or streaks on the pods. Damaged pods are not marketable although the food value of the peas is not affected.

The powdery mildew causes considerable damage in some sections of the country when conditions are favorable for the growth of the causal fungus. In the pea-growing sections of the States along the Pacific coast, and occasionally in other States, the application of control measures is required every year to produce a crop. Two different fungicides have been recommended, but only one is used to any extent on a commercial scale. In recent years, dusting the plants with sulphur has given good results. The first dusting should be done a soon as there is any sign of the disease, and another about a week o 10 days later. Sometimes as many as 6 or 7 applications are necessar to insure a crop. The application of a 4–4–50 bordeaux mixture ha been used, but better results have been obtained with sulphur dust which should be used whenever control measures must be applied Crop rotation and the turning under of the refuse left in the fiel

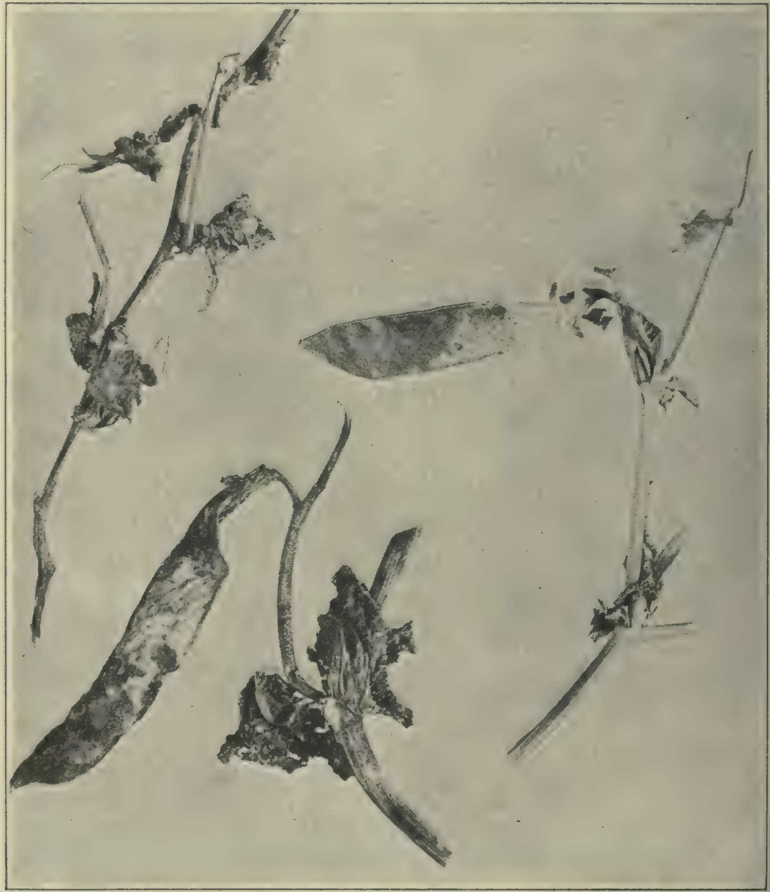

FIGURE 10.—*Septoria* blight on the pods, stems, and leaves. The round, black, slightly raised, smal domelike pimples are the receptacles in which the fruiting bodies (spores) of the parasite are enclosed When the spores escape from the receptacle they may be carried to other pods, stems, or leaves and star new infections.

immediately after harvest by deep plowing are practices that should be followed by the growers.

ANTHRACNOSE

The anthracnose of peas is caused by a fungus parasite (*Colletotrichum pisi* Pat.). It has been reported from several States, but in only one, Wisconsin, where it was severe for 1 or 2 years, has it been regarded as of any importance. On all parts of the plant above ground, the fungus causing anthracnose produces lesions that resemble those caused by the *Ascochyta* blight fungus. On the leaves it causes irregularly shaped, gray to brown spots; on the pods the spots are more nearly circular. The spots on the stem are elongated and ashen-colored.

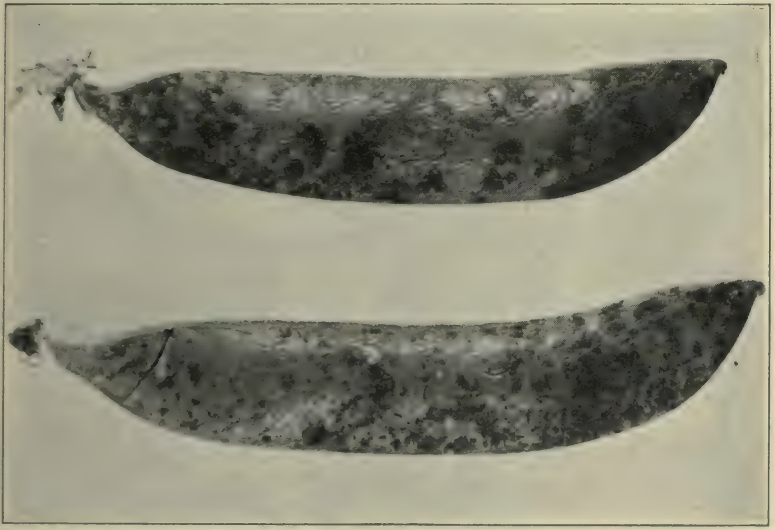

FIGURE 11.—Powdery mildew on pods, showing irregularly shaped brown spots and blotches. Pod infection reduces the market value. The symptoms may appear also on the leaves and stems as a white powdery talclike substance scattered over the surface.

The spores, or seedlike bodies, are formed in large numbers in the esions and may be distributed by rain or carried from one plant to nother on the bodies of insects, on farm implements, and possibly by he wind and by various other means. In the presence of moisture, he spores quickly germinate and cause new infections. It is not efinitely known how the organism survives the winter, but it is uspected that it may live from one season to the next in and on the eed and in the refuse left in the field from a previous crop.

No control measures have been worked out. It is probable that rop rotation, the plowing-under of the refuse left on the field, and the se of disease-free seed will help to hold the disease in check.

DOWNY MILDEW

Downy mildew is caused by a fungus (*Peronospora viciae* Berk.). his disease, although widely distributed, is not considered of conomic importance except in the States of Washington and California, and possibly in 1 or 2 other Western States. It causes a water-soaked condition of the affected parts and is further characterized by the white, downy or cottony growth (fig. 12) that may be found on any of the aboveground parts of the plants. The fungus also attacks different species of vetch, and from them it may be carried to the pea.

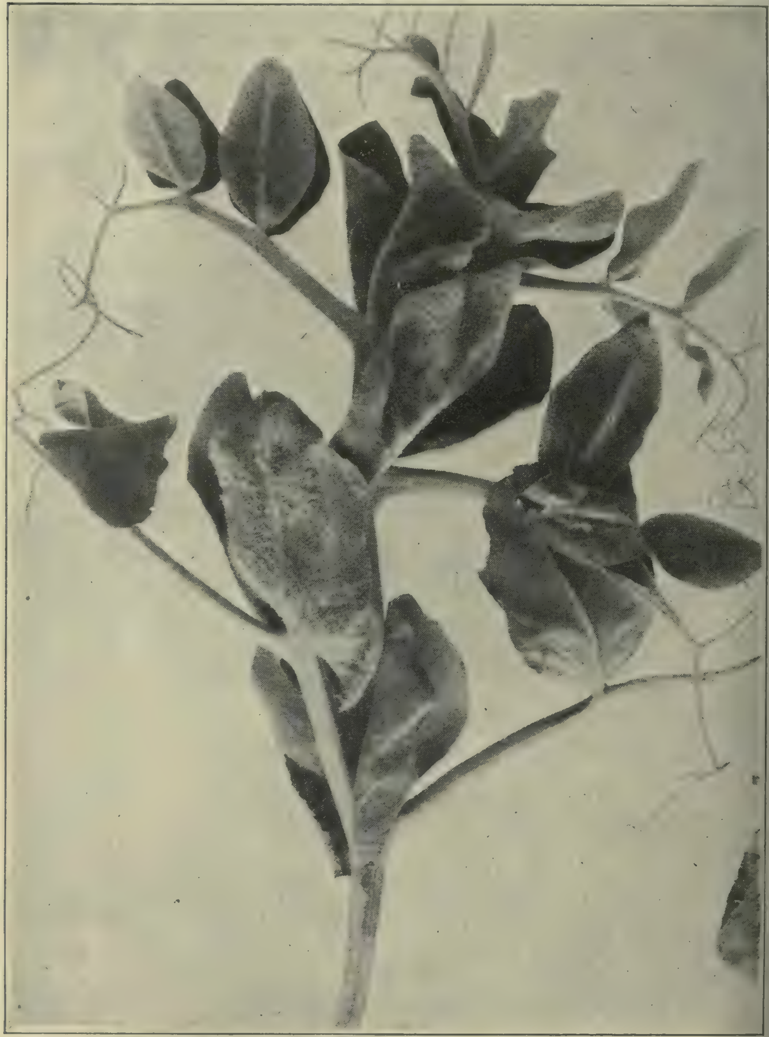

FIGURE 12.—Downy mildew. This disease sometimes grows through the pods and forms a mass of white mycelium within.

Control measures are not always required. When the disease is severe, it may be held in check by 2 or 3 applications of a 4–4–50 bordeaux mixture. The first application should be made as soon as there is any evidence of the fungus on any part of the plant. The applications should follow each other at intervals of 7 to 10 days.

MOSAIC

DESCRIPTION

Pea mosaic has been known for a number of years, but it has never become so widespread or destructive as bean mosaic. It probably never kills the plant but produces very characteristic symptoms.

Pea mosaic, unlike most of the mosaics of other plants, causes very little stunting of the host, since infection usually takes place rather late in the life of the plant. Leaves affected with mosaic show the intermixing of light and dark areas (fig. 13) characteristic of mosaics in general. The mottled areas are irregular in outline and may follow the small veinlets. In later stages these green areas enlarge and become yellowish green, giving the leaf a netted appearance. In general, the leaves of infected plants may be somewhat smaller than those of healthy plants, and frequently there is a slight curling of the edges. In severe cases of the disease the leaves may become somewhat curled, twisted, and dwarfed. The symptoms of the disease cannot be recognized on the stems or seeds, but the pods frequently are distorted, malformed, and dwarfed.

CAUSE

Pea mosaic is caused by a virus, the nature of which is little known. The spread of the disease is not clearly understood, but occasionally it can be transmitted by rubbing diseased leaves against the leaves of healthy plants. The pea aphis is also believed to be responsible for much of the secondary spread of the disease in the field. It has not been definitely proved that the disease is seed-borne, but preliminary evidence indicates that it may be carried in the seed in very small percentages. The disease as yet is not of great economic importance in the United States, but in certain pea-growing localities it causes some damage in reducing the yield and quality of the product.

CONTROL

There are no effective control measures known to combat the disease. Since the pea aphis is responsible for some of the spread in the field, the control of these insects may reduce the amount of spread. It is advisable in cases of slight infection to rogue out all infected plants as soon as they are seen, thereby reducing the possibility of secondary spread.

The relative resistance and susceptibility of the different pea varieties are not known. The market-garden types seem to be more susceptible than the canning or field types.

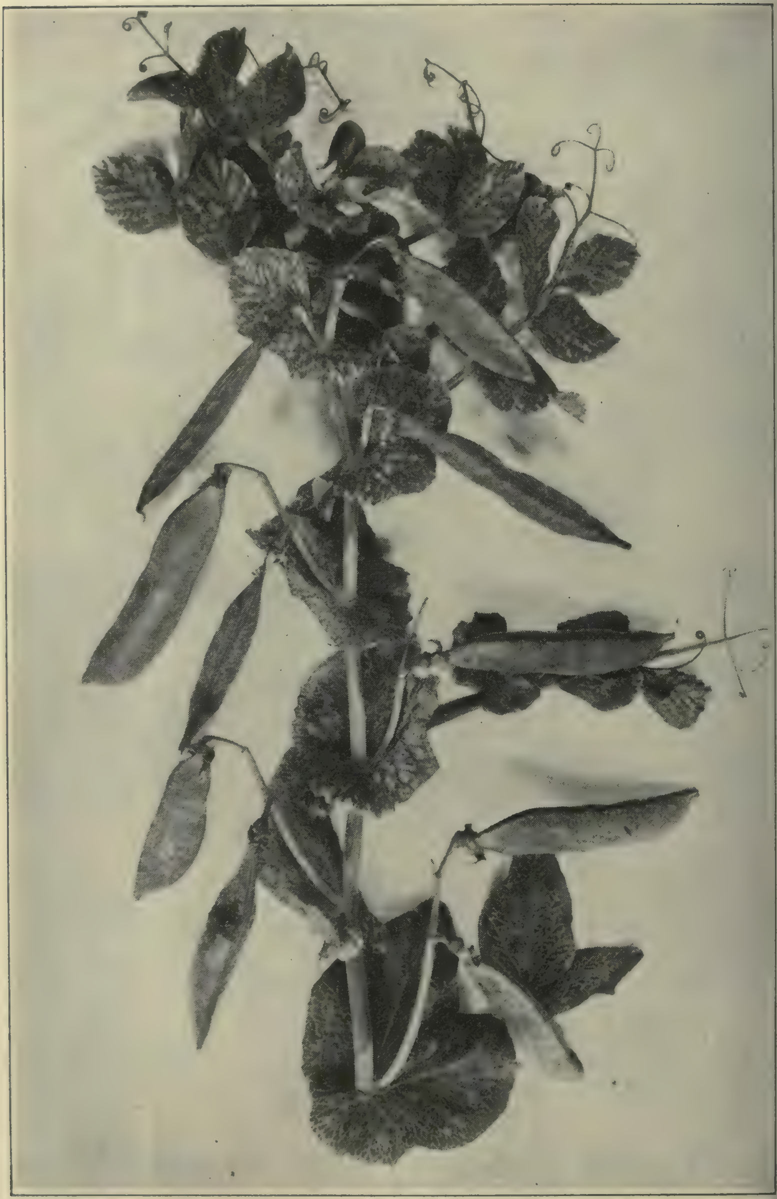

FIGURE 13.—Pea mosaic. Note the streaks of yellow and green, causing a mottled appearance of the infected leaves.

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U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1736

ANTHRAX

ANTHRAX is an infectious disease of livestock caused by a germ that exists in the soil of certain regions which are known as "anthrax districts." Such districts exist in practically all countries where livestock is raised.

Practically all species of livestock are susceptible to this disease, which is transmissible also to man. Cattle, horses, and sheep are most commonly affected and develop the disease in the acute form, with a resulting high death rate. Hogs acquire the disease for the most part in a chronic form from which they frequently recover.

The infection is taken in principally with feed and water, but the germ may also gain entrance through the skin and respiratory tract. Once in the body, the germs multiply rapidly; after death every drop of blood contains myriads of the disease-producing organisms.

The symptoms vary according to the species of animal affected and the acuteness of the attack. Sudden death occurs frequently among horses, cattle, and sheep. In addition to high temperature and labored breathing, cattle, horses, and mules commonly have doughy swellings beneath the skin, and frequently there are bloody exudates from the natural openings. Sheep most often have convulsions before death. In hogs swelling of the throat is the most common symptom.

A greatly swollen, dark, soft spleen, dark, tarry, poorly coagulating blood, hemorrhages, and watery infiltrations are the principal evidences of anthrax.

Control measures on anthrax-infected premises consist in prompt disposal of carcasses by cremation or deep burial, preventive vaccination, and wherever practicable, the fencing of badly infected lands and water holes. Roving dogs, carrion-eating birds, and flies should be controlled so far as possible.

When the course of the disease is not too rapid, antianthrax serum has a specific curative effect. So far as is known no other treatment is effective.

The control of anthrax is a major concern of the livestock industry. Consult and cooperate with your local veterinarian and livestock sanitary officials.

This bulletin supersedes Farmers' Bulletin 784, Anthrax or Charbon.

Washington, D.C. Issued October 1934

ANTHRAX

W. S. Gochenour, *senior veterinarian, Pathological Division, Bureau of Animal Industry*

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INTRODUCTION

ANTHRAX is an infectious disease of livestock caused by a specific micro-organism or germ known as the anthrax bacillus (*Bacillus anthracis*) and characterized in its most common form by a rapidly fatal course or by sudden death. The disease causes annual losses of many millions of dollars to the livestock industry. As it is also infectious to man, anthrax is a menace to public health.

SUSCEPTIBILITY OF ANIMALS

Practically all animals are susceptible in some degree to anthrax, but the herbivorous animals are most susceptible. Cattle, horses, sheep, goats, and wild herbivorous animals are most commonly affected, and in these animals the disease usually appears in the acute form which rapidly terminates in death.

Although hogs are susceptible to anthrax, they possess a resistance to the disease greater than that shown by the other species of domestic livestock. In hogs a relatively high percentage of affected animals recover.

Dogs and other carnivorous animals may become infected by eating the carcass of an animal dead of anthrax. Poultry, however, is not susceptible to the disease under ordinary conditions.

Anthrax is infectious to man also, being contracted through the handling of anthrax-infected carcasses, hides, wool, or hair and manifesting itself as a local infection of the skin or as an infection of the respiratory or digestive tracts. In the latter forms, the disease spreads rapidly throughout the body and terminates in death.

CAUSE OF THE DISEASE

Anthrax is caused by a specific micro-organism or germ which is indigenous to the soil in certain areas wherein it survives for long periods, especially in areas that are subject to periodic inundations or in low-lying marshy land.

These organisms in their active state (vegetative forms) are cylindrical in shape and grow in the presence of air. When they gain access to the animal body they multiply rapidly and invade the blood stream, producing a rapidly fatal blood infection or septicemia (fig. 1).

When these cylindrical rods are released from the animal body they produce, on access to the air, elliptical bodies known as spores, which are very resistant to heat, cold, drying, and exposure to disinfectants. In the soil these spores may live for years, ready to reproduce the disease in susceptible animals that may come in contact with them (fig. 2).

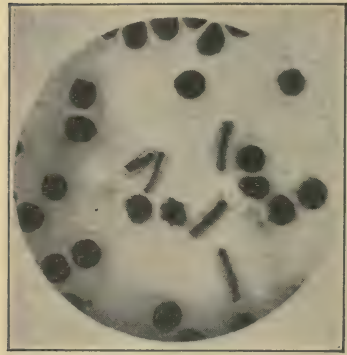

FIGURE 1.—Photomicrograph of blood from a sheep that died of anthrax, showing the cylindrical anthrax bacilli in their active state. The more or less round objects are blood corpuscles. Magnified about 500 diameters.

HISTORY

Although in all probability anthrax existed in very early times and acquired its name through the dark color of the blood of its victims, its nature was unknown until 1836 when its infectiousness was established through the transfer of the disease from one animal to another by inoculation and feeding the diseased blood.

The specific rod-shaped miscroscopic germs were first observed in the blood in 1849 by the German investigator, Pollender. The micro-organisms were also observed in 1850 by the French investigator, Davaine, who later (1865) showed their causal relationship to the disease, anthrax. In 1876 the German investigator, Robert Koch, cultivated the anthrax bacillus outside the animal body on an artificial culture medium.

GEOGRAPHICAL DISTRIBUTION AND SEASONAL OCCURRENCE

Anthrax is widely distributed, having appeared on every continent. Before the disease was known to be of an infectious nature and before systematic measures were taken to suppress it, heavy losses were sustained in many countries.

Being a disease indigenous to the soil, anthrax is more or less confined to certain districts, where it occurs almost every year; such areas are commonly designated as " anthrax districts." In such districts the disease makes its appearance during a more or less definite period of the year, usually in the summer, such periods being referred to as the " anthrax season." Isolated cases, however, may occur at any time, including the winter months when stock is not on pasture.

Since anthrax-contaminated soil is the source of the disease in livestock, most outbreaks occur when the animals are on pasture. It has been observed that hot, dry summers with scant growths of pasture, necessitating grazing close to the soil, are frequently followed by unusually large numbers of cases of anthrax. Likewise, a period of rainy weather followed by warm days appears to favor the occurrence of the disease. It is also a well-known fact that heavy losses from anthrax often follow in the wake of floods and periodic inundations of low-lying land.

In certain years the disease assumes a very virulent form, appearing simultaneously at a number of places, new centers of infection occurring in rapid succession, and soon it covers large areas, occasioning heavy losses of livestock. The cause of these cyclic waves is as yet unknown.

MODES OF INFECTION AND DISSEMINATION

It is generally considered that anthrax infection for the most part occurs by way of the digestive tract. Spore-laden soil is taken in with the feed principally while the animal is on pasture, although hay made on anthrax-contaminated lands may harbor virulent spores and cause the disease in stable-fed animals.

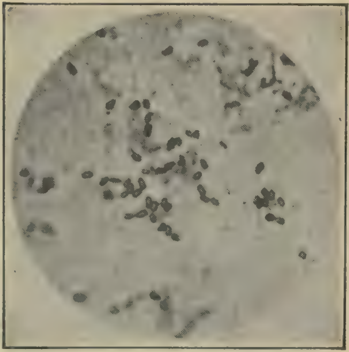

FIGURE 2.—Photomicrograph of anthrax culture showing the resistant elliptical anthrax spores. Magnified about 500 diameters.

Contaminated drinking water is also a potent source of infection. Water may become contaminated through the surface drainage of anthrax lands or from the carcasses of animals that died of anthrax, especially when they lie close to or in an upper branch of a stream or in a pond.

Infection may also occur by way of the skin through anthrax spores from the soil lodging in wounds and abrasions or through punctures made by biting insects that had previously fed on a diseased animal. It is possible that anthrax organisms may penetrate the unbroken skin, reach the deeper structures, and set up infection. Such evidence has already been obtained in human cases at least. Infection may also take place through the respiratory tract, the inhaled spores setting up a rapidly fatal form of pneumonia. This form of anthrax is recognized in man more often than in the lower animals.

As previously stated, soils contaminated with anthrax frequently remain dangerous for long periods, requiring only favorable climatic and moisture conditions to cause repeated outbreaks of the disease and the consequent reinfection of the land. Additional territory may in turn become contaminated through the wandering of diseased animals, which spread the germs with their excreta as they go and finally contaminate new land heavily with the countless numbers of micro-organisms that escape from the natural openings of their dead bodies.

Dogs and other carnivores, as well as the carrion-eating animals and birds, are potential spreaders of anthrax from one area to another. After feeding on an anthrax-infected carcass their bodies doubtlessly are heavily contaminated with anthrax spores and these may be carried to distant fields. Virulent anthrax spores were found, in an experiment, in the droppings of buzzards that previously had fed on an anthrax-infected carcass.

Some of the flying insects must be considered as potential spreaders of anthrax, feeding as they do on the blood of living animals or on the materials that escape from the natural openings. Animals sick of anthrax become easy prey to myriads of flies and other insects, both biting and nonbiting. Virulent anthrax organisms have repeatedly been found in or on the bodies of several species of flies, including blowflies taken from carcasses of animals dead from anthrax (fig. 3). Entomologists have shown that some of these flies and other insects travel great distances.

Streams contaminated with surface drainage from anthrax-infected land or by carcasses of animals dead of anthrax may convey the germs many miles downstream, infecting the territory through which they pass.

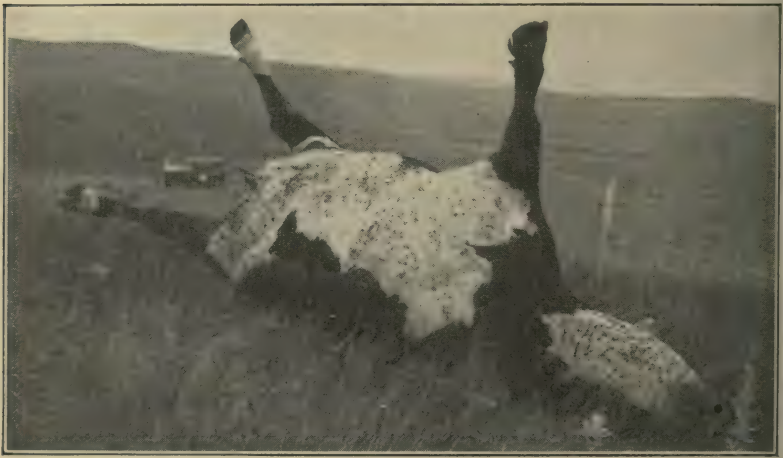

FIGURE 3.—Carcass of a cow dead of anthrax. Note the great number of flies on the carcass. Virulent anthrax germs were found on flies taken from this and one partly incinerated carcass on the same ranch. (Photograph by W. G. Bruce, Bureau of Entomology, U.S. Department of Agriculture.)

Anthrax may spread from one country to another through the interchange of infected hides, hair, wool, bone meal, fertilizer, forage, and other items closely related to animal life.

The Government endeavors to prevent the introduction of this disease into the United States through the administration by the Bureau of Animal Industry of regulations governing the sanitary handling and control of hides, skins, fleshings, hide cuttings, parings, glue stock, hair, wool and other animal by-products, and hay and straw of foreign origin.

SYMPTOMS

According to the course of the disease, anthrax is recognized in three forms: A peracute form, in which the interval between the first outward manifestation of symptoms and death is but a few hours or even minutes; an acute form, in which the disease lasts for a day or two; and a subacute form, in which the period between first symptoms and death or recovery extends beyond several days.

In the peracute form of the disease, death occurs so quickly that clinical symptoms are seldom observed. In the great majority of instances animals that when last seen were apparently in perfect health are found dead. Less often a seemingly healthy animal is seen to fall to the ground, go through a few convulsive movements, and die. Closer examination frequently shows blood-stained discharges from the nose, mouth, and anus. Peracute anthrax occurs most often in the beginning of an outbreak among cattle and is the most common form of the disease in sheep. Sudden death in cattle, sheep, and horses in areas where anthrax previously existed should always be viewed with suspicion and the owner should be on the lookout for anthrax.

In cattle, in addition to the peracute form of the disease in which few symptoms are seen, acute and subacute infections develop. In these forms there is first a stage of excitement, which is soon followed by depression. In this stage the animal lags behind, with the head hanging low, refuses to eat, and prefers to stand still or to lie down. Respiration is more rapid than normal and appears to be labored. Rumination ceases, and in milking cows the milk secretion is materially lessened. Pregnant animals may abort. At this stage of the disease the body temperature is elevated and may reach 180° F. Bloody discharges usually come from the natural body openings. When diarrhea sets in, the feces are usually blood-tinged. Small hemorrhages may be noted on the visible mucous membranes. Soft swellings that pit on pressure may develop over the body, but the more common sites are about the external genitalia and on the lower wall of the abdomen. The tongue also may show extensive swelling and dark discoloration.

Shortly before death respiration becomes extremely labored, the mucous membranes take on a bluish cast, and the temperature falls below normal.

In horses and mules, the first indication of disease may be severe colicky symptoms accompanied by the passage of blood-stained feces. Hot, painful, and rapidly progressing swellings frequently develop over the body, especially about the neck, lower abdomen, and external genitalia. Hemorrhages may be seen on the visible mucous membranes. There is loss of appetite and elevation of the body temperature.

In sheep and goats, anthrax occurs most often in the peracute form. Either the animal is found dead or dies shortly after the first symptoms are noted. The visible symptoms are unsteady gait, trembling, restlessness, difficult respiration, bloody discharges from the natural openings, blueness of the mucous membranes, and convulsions preceding death.

In hogs, when infection follows feeding on an anthrax-infected carcass, some of the animals may be found dead, not having shown any previous signs of illness. Others of the group may show symptoms of illness with rapidly progressing swellings about the throat, these swellings in some cases causing death by suffocation. A relatively large percentage of the group may become visibly sick for a few days, with or without moderate swellings about the throat, and recover. When hogs develop anthrax from sources other than feeding on anthrax-infected carcasses, the above-mentioned symptoms are observed, except that sudden death without visible symptoms is rare.

In dogs affected with anthrax, swellings may occur about the head and throat.

In man, anthrax usually occurs as a primary localized infection of the skin in the form of a carbuncle or as an infection of the lungs known as "woolsorter's disease." In countries where the flesh of animals dead of disease is eaten, an abdominal form of anthrax has been reported.

Skin infections result from the handling of carcasses of animals dead of anthrax or the hides, hair, or wool from such carcasses. Originating as localized infections in the form of small pimples, the lesions develop rapidly and may terminate in a fatal septicemia or blood poisoning. Prompt medical attention is most important whenever anthrax infection is suspected.

The pulmonary form of the disease results from the inhalation of anthrax spores in factories where hair and wool are processed. The course of this form of anthrax is very rapid and terminates fatally.

ANATOMICAL CHANGES

If anthrax is suspected, the stockman should consult a veterinarian at once rather than open up a carcass for the purpose of making a definite diagnosis. The seriousness of such a mistake can hardly be overestimated owing to the greatly increased danger of spreading the disease when the body is opened and discharges from it escape. Post-mortem examination in suspected cases of anthrax should be made only by a qualified veterinarian who is prepared to take all necessary precautions against infecting himself and the premises.

Carcasses of animals dead of anthrax decompose rapidly and soon become greatly bloated. The natural post-mortem stiffening of the muscles is incomplete. Dark blood escapes as a rule from the natural openings, and the visible mucous membranes are dark blue in color and frequently show hemorrhages. The blood is considerably darker than normal, does not clot readily, and is frequently spoken of as being tarry. Hemorrhages beneath the skin are common. Clear or somewhat blood-tinged gelatinous exudates are found between the muscles and beneath the skin, especially in the areas where the swellings were seen before death.

With rare exceptions the spleen shows characteristic changes, which are of considerable assistance in making a diagnosis of anthrax. This organ is greatly enlarged, and the splenic pulp is dark red to blackish in color and soft, or even semifluid in consistency.

The liver and kidneys are congested and enlarged and frequently show areas of hemorrhage on their surfaces. The heart muscle is grayish red and flabby. The lungs are congested and contain serum. The mucous membranes of the trachea and bronchi are red and dotted with hemorrhages of varying sizes. The mucous membrane of the intestines is greatly swollen and hemorrhagic.

In hogs the outstanding anatomical changes are confined principally to the region of the throat, where there is a marked gelatinous and hemorrhagic condition of the connective tissues and lymphatic glands. The tonsils are enlarged and frequently covered with a dark, discolored false membrane. Swelling of the structures forming the glottis is also observed. Although the spleen is frequently normal in size and color, enlarged, dark, and soft spleens may be found in cases where the disease has become generalized.

Local lesions of long standing are sometimes found in the throat region of slaughtered hogs that had shown no visible signs of anthrax during their life and which were apparently healthy prior to slaughter. In these cases the disease is confined to the pharynx and the adjacent tissues including the lymphatic glands of that region. Localization of anthrax in the mesenteric glands has also been observed. In this chronic localized type of anthrax the lymph glands of the head, especially the submaxillary glands, may be either slightly or greatly enlarged, hard, and fibrous. The cut surface presents a mottled appearance, being produced by areas which are brick red in color, patches or streaks having a dull gray, parboiled appearance and necrotic foci which may be dry and cheesy. One or both tonsils may show areas of degeneration and necrosis ranging in size from that of a pinhead to that of a silver dollar. The epiglottis may be greatly swollen (fig. 4).

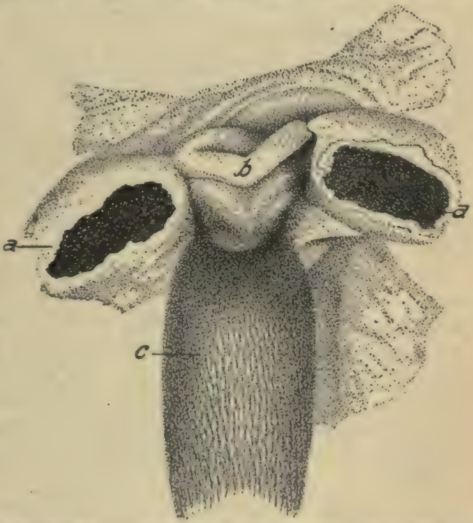

FIGURE 4.—*a*, Ulcerated tonsils of a hog affected with the chronic form of anthrax. The other organs shown are epiglottis *b* and tongue *c*.

DIAGNOSIS

When an animal dies within an anthrax district or on or near premises where the disease has appeared previously, it is very important to know definitely whether the death was due to anthrax. Lack of such information has often been responsible for heavy losses of livestock and, at times, the loss of human lives. Whenever there is a possibility of anthrax, it is advisable to have the cause of death determined by a competent veterinarian. If local veterinary service is not available the State livestock sanitary officials should be consulted.

The diagnosis of anthrax from clinical symptoms may at times be difficult, especially when the disease occurs at a time when it is not prevalent and on premises that have formerly been free from the infection. In peracute anthrax, death is so sudden and the clinical symptoms are so meager that a definite diagnosis is impossible without the aid of laboratory examination. Cerebral hemorrhage, sunstroke, lead poisoning, or some acutely fatal digestive disturbance may be confused with peracute anthrax especially if it occurs in the so-called anthrax districts.

In the less acute cases of anthrax, there may be an escape of bloody exudate from the natural openings, together with swellings beneath the skin. However, somewhat similar swellings are observed in malignant edema, hemorrhagic septicemia, tick fever, and sweetclover poisoning of cattle and purpura hemorrhagica in horses. Although swellings are found in blackleg of cattle, such swellings crackle under pressure because of their air content and are readily distinguishable from the gasless swellings of anthrax that have a doughy consistence and pit on pressure. In all of the above diseases, with the possible exception of malignant edema, blood-stained discharges may at times be seen. In hogs, malignant edema involving the throat region may be mistaken for anthrax, and a definite diagnosis can be made only by laboratory examination of some of the affected tissues.

Any previous occurrence of anthrax on the premises is sufficient reason for considering anthrax as a possible cause of any deaths among livestock that cannot be clearly attributed to other causes. In a large number of such instances a tentative diagnosis of anthrax can be substantiated by laboratory examination. When a laboratory examination is desired, suitable specimens should be collected by a qualified veterinarian. In case professional services are not available and the samples are to be collected by others, the greatest care should be taken by the operator to prevent infecting himself. Heavy rubber gloves should be used to prevent the infectious material from coming in contact with the hands.

A few drops of blood deposited in a small wide-mouthed bottle or jar and the container rolled around so as to spread the blood in a thin film that will dry quickly on the bottom or side walls makes a very satisfactory specimen for bacteriological examination. Larger quantities of blood are unsatisfactory in that putrefaction may set in and destroy any anthrax organisms that may be present. Furthermore, the forwarding of larger quantities of such blood by common carrier is a dangerous procedure which should not be undertaken. The few drops of blood that are required may be collected from a small cut made over the jugular vein or at the base of the ear immediately before the carcass is buried or cremated.

Another method of obtaining a specimen, but a less satisfactory one, is as follows: Remove an ear, place it in a tight container and pack it in a strong box for shipment to the laboratory. As in the case of large quantities of blood, however, there is danger of putrefaction setting in.

After the samples are collected, it is advisable to destroy the operating knife with the carcass and thoroughly disinfect the hands and arms with a solution of 1 part bichloride of mercury to 1,000 parts of water. This solution should be mixed in and used from a wooden bucket or stoneware crock. As this disinfectant, if swallowed, is very poisonous to man and animals, precautions should be taken accordingly.

No attempts should be made by the layman to collect specimens of the internal organs. The body cavities should be opened only by an experienced veterinarian who is able to protect himself and the premises should the animal's death be due to anthrax.

CONTROL MEASURES

Anthrax is a menace to the livestock industry and requires the concerted defensive action of livestock sanitary officials, local veterinarians, and owners. When the disease threatens or invades one's herd, it is advisable to obtain the assistance of a qualified veterinarian or State official, who is in a position to advise intelligently on the most effective means of control.

The first line of defense against anthrax consists of the prompt and proper disposal of animals dead of the disease.

The second line of defense is vaccination for prevention or cure in accordance with methods recommended by livestock sanitary officials and other experienced veterinarians.

The third line of defense consists in fencing, wherever practicable, to exclude livestock from pools, swamp land, and pastures where anthrax infection is known to exist.

DISPOSAL OF CARCASSES AND DISINFECTION

In the control of anthrax prompt and effective disposal of carcasses is of greatest importance. It is good practice to dispose of all animal carcasses properly, especially in an anthrax area, even though the possibility of anthrax may at the time seem remote. This can be accomplished either by complete cremation or deep burial under a layer of quicklime covered with at least 6 feet of earth. Carcasses should not be buried in low swampy land or adjacent to streams where overflow might inundate the grave, or on a hillside where there is a possibility of subsurface drainage reaching the surface at lower places nearby. The area above and around the grave should be saturated with oil and burned over. The method to be employed will be governed by the prevailing weather conditions and the relative promptness and ease with which each procedure can be carried out at the place where disposal becomes an issue.

In disposing of a dead animal the following method is recommended: Immediately after finding the animal, cover it with kerosene or crude oil to keep flies, dogs, buzzards, crows, and vermin from the carcass until it is disposed of. If conditions permit, cremate or bury the carcass where it is found. If moving to a more suitable site is necessary, take the greatest care to prevent any discharges or hair from contaminating the soil over which the carcass is moved. Consequently, never permit a carcass to be dragged. A stone boat or sled may be used as a means of conveyance. Thoroughly disinfect or burn any equipment used in moving anthrax-infected carcasses. Avoid actual contact with the germ-laden body; this can be done through the use of properly applied ropes and poles, which may then be burned. Prepare a solution of bichloride of mercury to disinfect the hands and boots or shoes of the operator after the disposal of the carcasses has been completed.

It is advisable, if possible, to have the disposal of anthrax-infected carcasses conducted under the supervision of a qualified veterinarian who from experience can advise on the most effective and economical means of destroying the carcass and disinfecting whatever materials may have become contaminated by the animal or carcass.

The cremation of the carcass of a sheep or hog is not difficult, but the complete destruction of that of a horse or cow is more of a problem. There are several methods that give satisfactory results in the cremation of large carcasses. One of these is to dig two trenches approximately 2 feet wide and 18 inches deep, crossing each other at right angles, over which a grating of green posts is laid, followed by several layers of dry rails or split logs. After the carcass is placed on this pyre, straw and either kerosene or oil are used to start a good fire. Additional fuel is added as needed. A covering of sheet iron or green logs tends to conserve the heat and hasten the destruction of the carcass.

Another method requires no trenches. Oil is applied freely to the carcass, which is then covered with a liberal quantity of straw, and this in turn is covered with a thick layer of heavy, moderately dry manure. Burning the straw generates sufficient heat to start the manure burning, which continues slowly until the carcass is reduced to ashes. This method, which is shown in part on the cover page, is slower than the one which involves the use of a rail pyre. There should be plenty of oil, straw, and manure, and the carcass should be fully covered.

When anthrax is prevalent, it is advisable for the owner to keep all his own dogs tied up and to discourage in every possible way stray dogs from coming on the premises. There is always a possibility of such animals having eaten of an anthrax carcass and so becoming spreaders of the infection.

For the same reason action should be taken to protect livestock from the dangers of buzzard and crow roosts. Protection from flies and biting insects so far as practicable is advisable also.

When anthrax occurs in stabled animals, prompt and thorough disinfection of the quarters should follow the removal of the dead animals. Where sick animals are being treated, every precaution should be taken to prevent spread of the infection through contaminated excreta. There is always a possibility of rats or mice transferring contamination to the hayloft or feed storerooms. Therefore special effort should be made in anthrax districts to get rid of these pests.

Of the disinfectants, lye is one of the most effective. For disinfection of premises against anthrax, a 5-percent solution is recommended. To prepare such a solution 2½ pounds of commercial lye containing 94 percent of sodium hydroxide is dissolved in 5½ gallons of water. Where a whitewash is not objectionable, water-slaked (not air-slaked) lime may be added to the lye solution in the proportion of 2½ pounds of lime to each 5½ gallons of lye solution for the purpose of preventing the transformation of the active principle, sodium hydroxide, into sodium carbonate, which is considerably less effective as a germicide. It is advisable to use the lye or lye-and-lime solution as soon as it is prepared. All places to be disinfected should be thoroughly soaked with the disinfectant, which should be allowed to remain on for at least a day and should then be thoroughly washed off with clean water before the livestock are returned.

Manure from a stable where deaths from anthrax have occurred should be burned or deeply buried or, if this is impracticable, disinfected with very liberal applications of a 5-percent solution of lye. However, it is questionable whether any reasonably heavy applications of lye solution would disinfect completely large quantities of manure. It is impossible, therefore, to make general recommendations on the disposal or disinfection of manure that would be efficient and practicable under all conditions. Methods of procedure, therefore, should be left to the judgment of a qualified veterinarian.

PREVENTIVE VACCINATION

Where anthrax appears more or less regularly each year, vaccination affords the best means of holding the losses to a minimum.

Proper immunization against anthrax is a highly technical problem that involves an understanding of the principles of immunity, as well as expert knowledge of the available immunizing agents, the nature of each product, the immunizing value of each, and its limitations. Anthrax vaccination is, therefore, a procedure that should be under the immediate supervision of a qualified veterinarian.

Where vaccination is necessarily an annual procedure, it should be performed in advance of the anthrax season or at least before anthrax makes its appearance. There is a possibility that vaccination may be followed by an initial state of lowered resistance preceding the establishment of immunity, and exposure to anthrax during this period of increased susceptibility may prove costly. In fact, field observers have frequently witnessed the rapid development of cases of anthrax within several days after vaccination when it was performed after the disease had started. This, it was believed, could have been avoided had the vaccination been performed before the outbreak occurred.

It should be borne in mind, however, that vaccination is not 100 percent effective regardless of the method of vaccination or the vaccine that is used. It is not uncommon for anthrax to develop in an occasional animal even when it is vaccinated with an anthrax biologic that apparently affords protection to the rest of the herd. Whether this is due to the failure of the individual to respond properly to vaccination or whether that particular animal picked up a sufficient number of anthrax spores to break down any degree of immunity cannot be determined. In experimental work in which a number of similarly vaccinated animals are given identical exposures to anthrax, the occasional loss of a properly vaccinated animal seems to point to the failure of the particular individual to respond properly to the vaccination that was given rather than to a fault in the vaccine.

With the knowledge that anthrax vaccination is not 100 percent effective an occasional loss from anthrax in a vaccinated herd does not constitute grounds for questioning the value of the biologic that was used; neither does it justify hasty revaccination of the herd.

The following varieties of anthrax-immunizing agents are now available in the United States: Antianthrax serum, anthrax aggressin, anthrax antigen, anthrax bacterin, antianthrax serum and anthrax-spore vaccine, single-injection anthrax-spore vaccine (in liquid or pill form), double- or triple-injection anthrax-spore vaccine (in liquid or pill form), anthrax-spore vaccine (intradermic), anthrax-spore vaccine in saponin solution. The first four of these comprise the sterile anthrax products and the remainder the living-spore anthrax products.

The selection of the anthrax biologic to be used on a given lot of animals should be left to the local veterinarian or State livestock sanitary officials who, because of their experience and knowledge of the local conditions, are in a position to know which products are best suited to the needs of the herd.

STERILE ANTHRAX-IMMUNIZING AGENTS

Antianthrax serum is made from the fluid part of the blood of horses, mules, or cattle that have undergone a process of hyperimmunization to anthrax. This process consists in beginning with injections of small quantities of weakened anthrax cultures, followed by a number of injections both larger in quantity and of increased virulence, until the animal can withstand enormous doses of virulent anthrax culture. By this means the blood serum of the hyperimmunized animal becomes heavily charged with anthrax-immune bodies. When such serum is collected, properly preserved, and stored it will retain its potency for several years. The serum contains no living micro-organisms or spores.

Antianthrax serum injected into animals (fig. 5) produces increased resistance to anthrax as soon as it is absorbed, and the resistance is in direct proportion to the quantity of serum that is given. It is of value both as a preventive and as a curative agent. The immunity which it confers, however, is of relatively short duration. Under experimental conditions the serum afforded complete protection at 4 days after its administration, but 16 days after vaccination the protection was reduced by one-half.

As a preventive, therefore, the use of antianthrax serum is advisable when immediate protection is the principal object even though the immunity is but temporary. When serum alone has been given to the apparently healthy animals in an infected herd, it should be followed 10 days later by vaccination with a biologic that will produce a more enduring immunity.

Anthrax aggressin, anthrax bacterin, and anthrax antigen differ from antianthrax serum in that they stimulate the treated animal to produce immune bodies (active immunity), whereas the serum treatment is merely a mechanical transference of already produced immune bodies to the treated animal (passive immunity). Naturally the protection afforded by aggressin, bacterin, or antigen would not become established as early as that established with serum, but it would be of longer duration. These three products, being sterile, are in themselves incapable of producing disease in the treated animal and are, therefore, safer than the living-spore anthrax vaccines.

LIVING-SPORE ANTHRAX PRODUCTS

All anthrax-spore vaccines are composed of living anthrax spores and are prepared in either liquid or solid form (pellets). These products may be used alone or in combination with antianthrax serum. The spores in these vaccines are so weakened that under ordinary conditions they will not produce the disease in livestock, if the vaccines are administered according to directions. However, a few individual animals are unusually susceptible and may react severely to vaccination with these spore vaccines, and occasionally an animal may die as a direct result of the vaccination (vaccination anthrax). For this reason, it is ordinarily inadvisable to use living-spore anthrax vaccines on premises where the disease has not existed previously or where there is reason to believe that previous infections have died out.

When these living-spore vaccines are used to control anthrax the greatest care should be taken to prevent contamination of the soil with the vaccine. Although the spores have been weakened, there is no definite assurance that they may not, under favorable soil conditions, again return to a virulent state and establish a new center of infection. Thorough disinfection of the restraining chute and the floor or ground where the vaccination was performed and prompt disposal of the empty vaccine containers by burning are recommended.

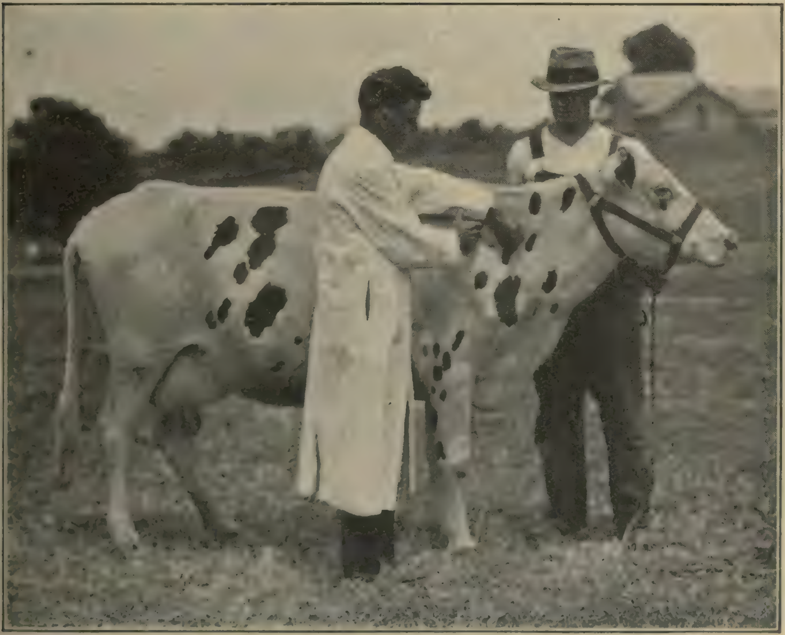

FIGURE 5.—Vaccinating a cow to produce immunity against anthrax.

Experience has shown that the living-spore vaccines produce a higher degree of immunity than do the sterile anthrax and as a rule vaccination with any of the living-spore vaccines used either alone or in combination with serum, is followed by an active immunity which lasts sufficiently long to carry the animal through the usual anthrax season. However, in some years anthrax makes its appearance in a highly virulent form, and in these years the artificial immunity which can be produced by vaccination does not always protect against infection.

FENCING AND OTHER CONTROL MEASURES

The third line of defense against anthrax consists of appropriate measures to prevent the introduction of the infection on anthrax-free premises and keeping livestock off the most dangerous parts of infected premises.

The principal concern of owners of anthrax-free premises is to prevent the introduction of the infection. Although the disease can be introduced through means which are beyond man's control, every effort should be made to guard against possible introduction by needless or faulty vaccination with living-spore anthrax vaccines, roaming dogs, especially when anthrax is prevalent in the vicinity, and the use of hay, straw, or other forage originating on premises where anthrax infection is known to exist. Livestock should also be protected from the potential dangers of buzzard and crow roosts. This can to a certain extent be accomplished by fencing off a small area about each tree containing a buzzard or crow roost.

Thorough inspection of premises where outbreaks of anthrax have occurred may disclose pools or marshlands that are potential sources of infection. Such places, as well as parts of pasture lands known to be heavily infected, should be fenced off so far as is practicable, since vaccination may fail to produce an immunity which is strong enough to protect against the heavy exposure that might be acquired in such heavily infected places.

TREATMENT

When the progress of the disease is not too rapid, treatment with large doses of antianthrax serum administered by a qualified veterinarian is frequently successful. When used either as a preventive or as a curative there is no danger of giving an overdose of the serum, but there is a possibility of giving quantities which are insufficient to accomplish their purpose. No other known product, drug, or combination of drugs can be depended on to cure an established case of anthrax in animals.

INDIVIDUAL RESPONSIBILITY AND COOPERATION

From both an economic and public-health standpoint, anthrax is a dreaded disease against which every means of suppression needs to be exerted. The suddenness with which anthrax strikes, the heavy toll that it takes, the long life of the infection in the soil, and the many ways in which the disease may be spread, make the problem of control a common cause to which every livestock owner should be a contributor. To this end, all persons concerned are in duty bound to put into effect every known measure of combating the disease and to cooperate to the fullest extent with the local veterinarian and livestock sanitary officials who are charged with the responsibility of controlling diseases of livestock.

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U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1737

STOP GULLIES

SAVE YOUR FARM

GULLIES CAN BE STOPPED OR HEALED

STOPPING a gully commonly means checking it from further active erosion—not filling it up. Simple methods of stopping gullies in the central part of the United States have been found that can be applied easily on the farm.

Many farmers have at times worked hard cutting trees or brush and thrown them down loosely into gullies in a sincere but ineffective effort to stop erosion. But the water has gone on steadily cutting deeper, and rain, frost, and wind have kept on cutting the gully wider. Much time, labor, and money have thus been wasted in efforts to stop more of the farm from washing away.

Gully erosion may be checked in several ways. A simple way is to "heal" the gullies by establishing a protective cover of trees, vines, or grasses over the surface. In "healing" or stopping the gullies, the necessary steps are (1) construct temporary check dams in the gully to catch up loose soil in which to plant trees, vines, or grasses; (2) slope the banks to an angle of repose (about 30 percent), which will also serve to put into the gully topsoil necessary for stimulating good growth; (3) plant trees, vines, or grasses selected for their ability to grow quickly and spread their roots in the soil and their tops over the soil; and (4) protect the vegetative cover from fire, livestock, and overcutting. In shallow, short gullies it will often be unnecessary to build any check dams except at or around the gully head or heads—the most critical point in an active gully.

Washington, D.C. September 1934

STOP GULLIES—SAVE YOUR FARM

By Wilbur R. Mattoon, *extension forester, Forest Service*

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BEFORE AND AFTER STOPPING A GULLY

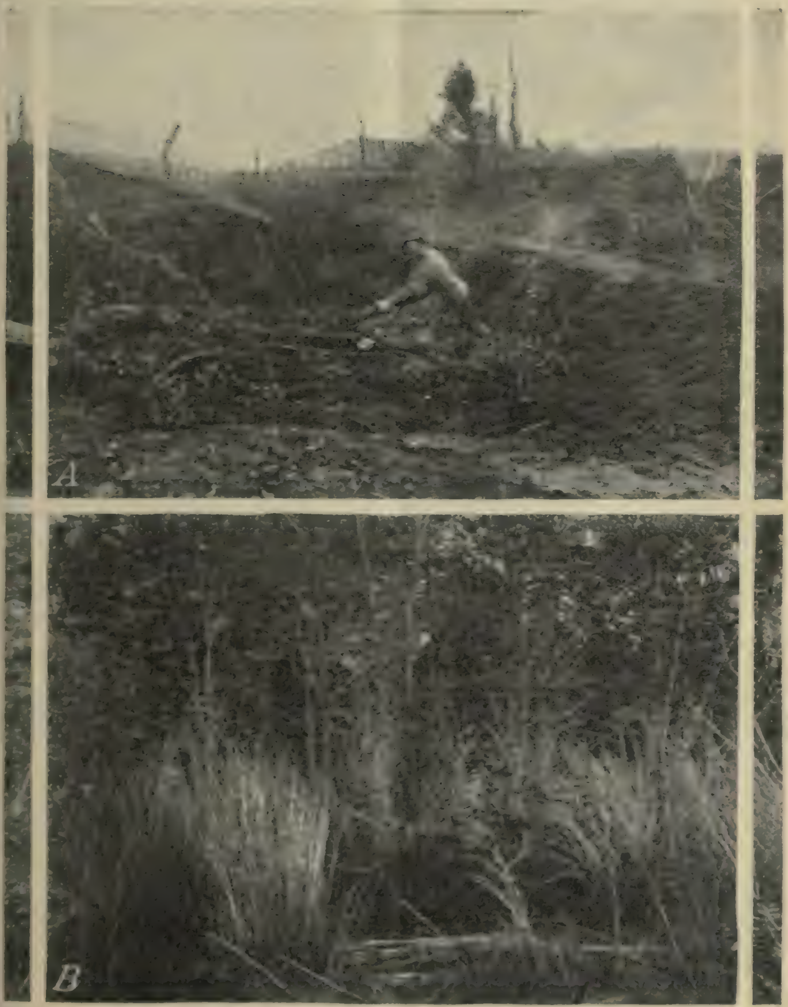

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Figure 1.—*A*, Building a brush dam is the first step in healing a farm gully. Dams should be well built to avoid being undermined or cut out at the ends (western Tennessee). *B*, The same dam a few years later. The gully has been completely "healed" by planting black locust trees and protecting them from fire and livestock. Broomsedge grass, lespedeza, and other plants have come in.

HOW TO STOP OR HEAL GULLIES

Have you watched gullies eat into your fields or pastures and wished you knew how to stop them?

Many farmers have thrown brush, wire, or even old automobile bodies into gullies in an effort to stop them and yet have seen the gullies eat further up into their farms.

There is a way to stop or heal gullies and large washes that any farmer can successfully follow, even including the case of the occasional huge gully.

Washes and small gullies in fields or pastures can be filled up at small expense and the land saved or reclaimed for use in crops or pasture. The soil must be carefully worked and terraced if it is in fields, or sodded if in pastures. With a little attention the soil in large gullies can be kept from breaking out and washing, and the gully be put to profitable use.

Gullies on the farm are like sores on the body—both can be healed. Gullies, large and small, can be healed successfully by restoring a protective vegetative cover. For hundreds of thousands of years in the past, trees, shrubs, vines, and grasses have grown and formed a protective cover over the soil. Washes or gullies did not begin until this natural protective cover was cut away, killed by fire, or eaten out by livestock. Bad cultivation speeded it up.

The secret, therefore, of healing gullies is either to give nature a chance to reestablish some vegetative growth or, quicker and surer, to plant trees, vines, grasses, legumes or other plants, and protect them from fire, overcutting by man, and overgrazing by livestock.

The secret of stopping gullies lies in healing the surface, particularly the heads and banks where soil erosion is going on most actively.

The necessary steps for healing gullies are: (1) Build small check dams; (2) slope off the steep banks and get topsoil behind the dams and on the gully slopes; (3) plant trees, shrubs, vines, or grasses;[1] and (4) protect all vegetative growth from fire, the ax, and livestock. Dams will be unnecessary in short, shallow gullies.[1]

The aim of this publication is to tell farmers how they can stop or heal their gullies by the method of establishing stands of trees, vines, or grasses as a protective soil cover.[2]

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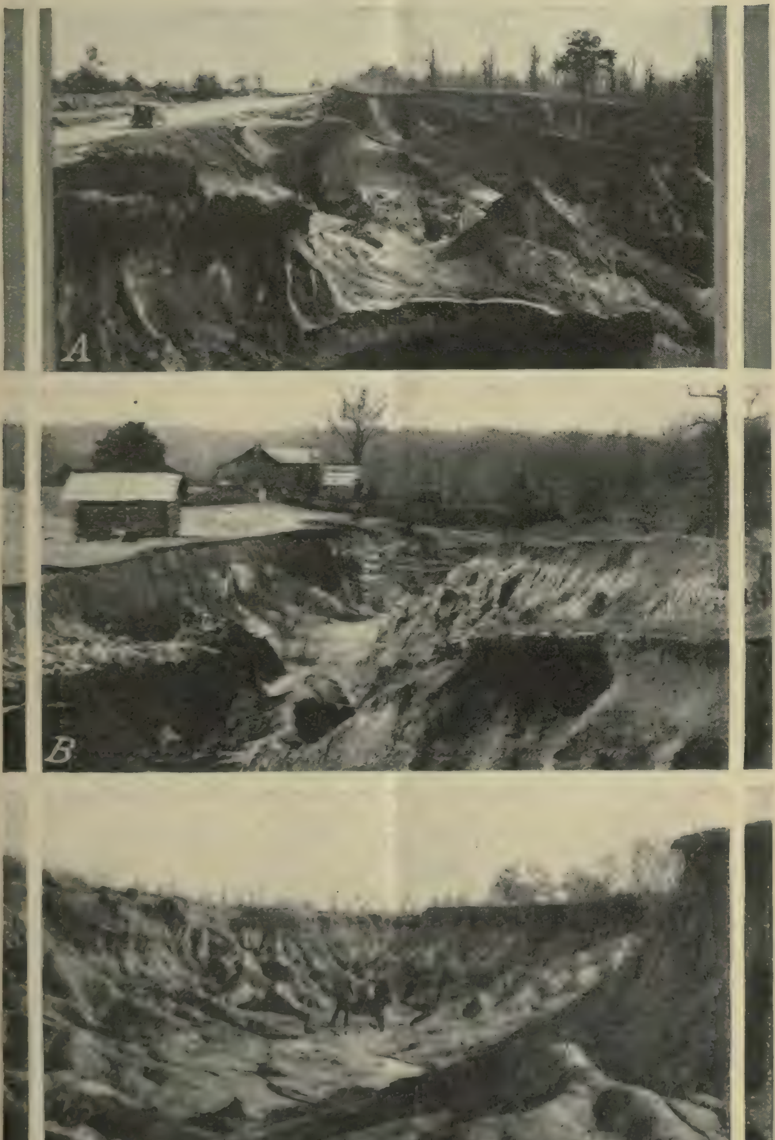
[1] This method has been applied on a practical scale since 1914 in western Tennessee.

[2] Reference should be made to Farmers' Bulletin 1697, Using Soil-binding Plants to Reclaim Gullies in the South. Reclamation of gullies for cultivation, by brush dams or where required by more elaborate structures, is explained in Farmers' Bulletin 1234, Gullies: How to Control and Reclaim Them. Use of terraces for protecting cultivated lands against erosion is described in Farmers' Bulletin 1669, Farm Terracing.

GULLIES, GULLIES, GULLIES



F 242955, F 40117A, F 39339A

FIGURE 2.—*A*, State highway that is dangerous to travel because it is almost engulfed by a huge gully on each side. *B*, Farm home that will probably soon be abandoned on account of the approaching gully. It started in a road which ran down the hill. *C*, Thousands of acres of good land have been eaten away in the midst of farm fields. The owners have to pay taxes upon their impoverished farms.

BAD PRACTICES THAT CAUSE GULLIES

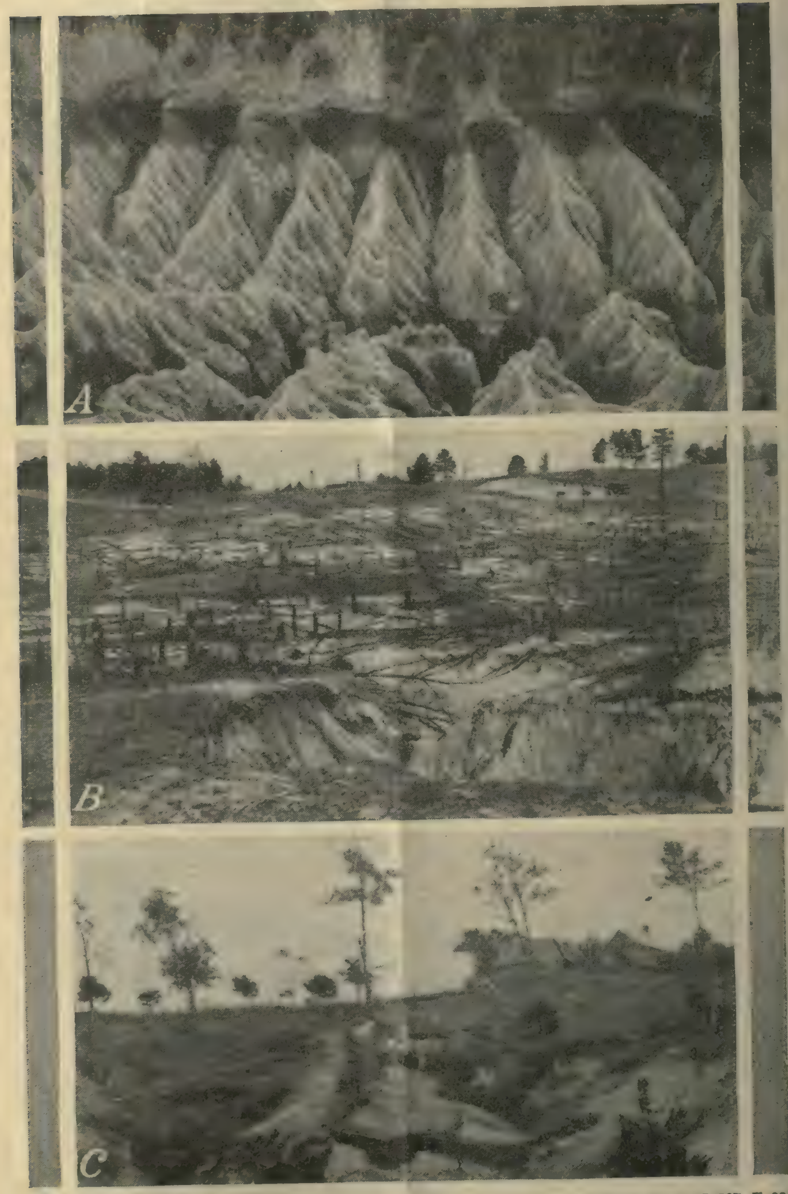


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FIGURE 3.—*A*, This is not a sleet storm on tree branches, but the result of bad cultivation practices. Cotton and corn were planted in rows up and down the hills instead of on the contour or level. Vast gullying in the Southern States has been started in this way. *B*, Cutting the trees, burning the land, and allowing cattle to graze the existing forage have been important causes of washing and gullying. A vegetative cover is nature's prime protection for the soil. *C*, Overgrazing by livestock is one of the prevailing causes of erosion and gullying such as has taken place on this farm hillside near the house and barn.

SOME RESULTS OF EROSION

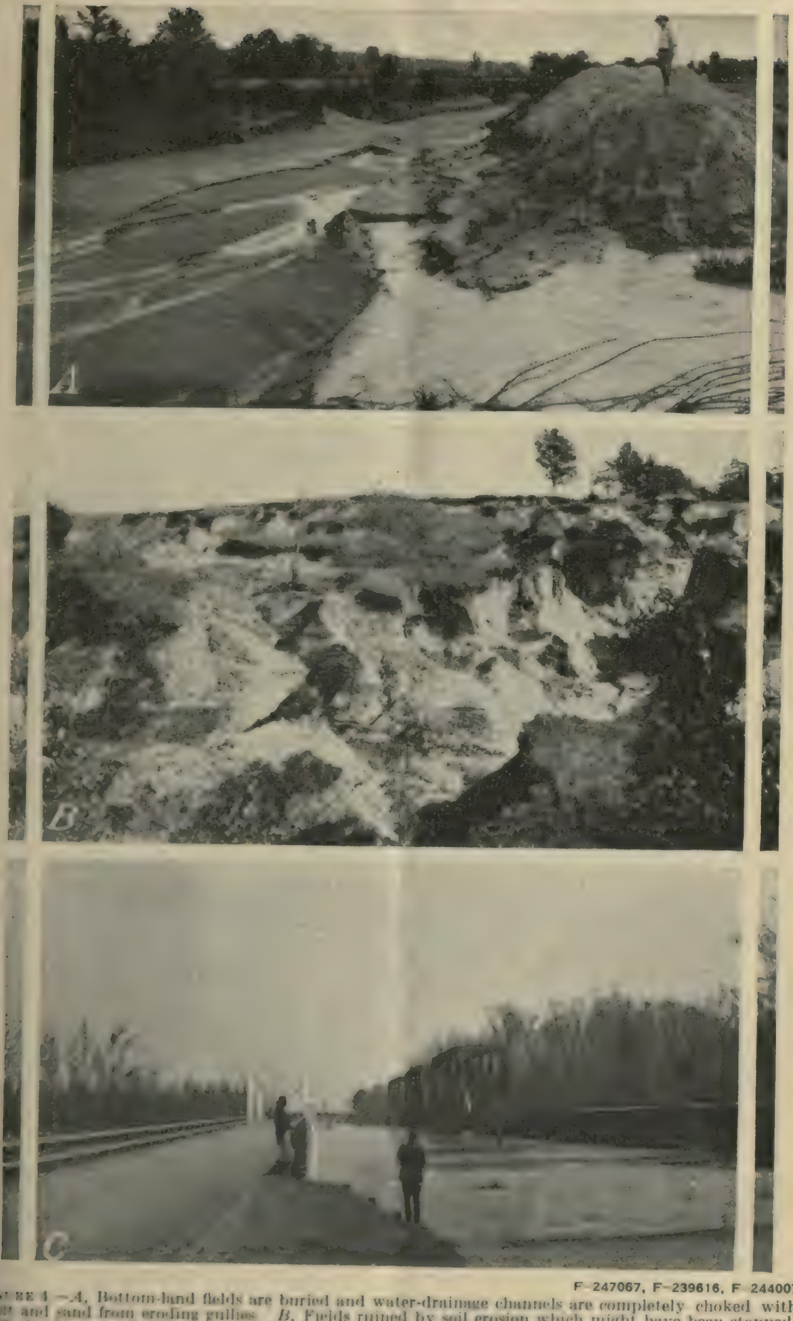

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FIGURE 3.—*A*, Bottom-land fields are buried and water-drainage channels are completely choked with silt and sand from eroding gullies. *B*, Fields ruined by soil erosion which might have been stopped. The land is now a liability to the owner and will likely revert to the county or State because of delinquent taxes. *C*, Often one quarter of the volume of floods is due to the load of silt and sand held in suspension or carried along the stream bottoms. Water channels clogged with eroded material also greatly increase the height of floods. Floods will decrease if our lands are rightly handled and kept from eroding.

HOW NATURE HEALS GULLIES

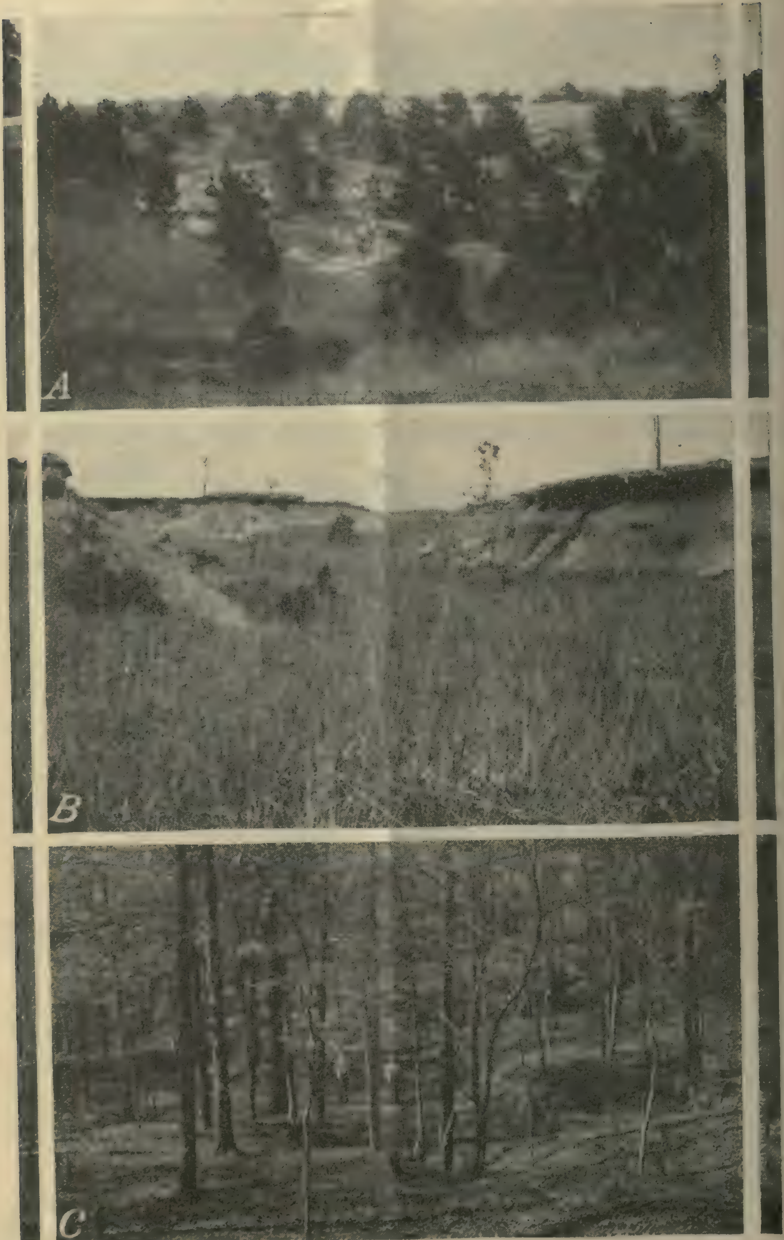

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FIGURE 5.—*A*, As the result of keeping out fire and giving nature a chance this abandoned field is coming up to shortleaf yellow pine. A common and costly mistake of some farmers is to cut trees growing in or near gullies and throw them loosely into the gullies. Trees are a means of permanently holding the soil in place. *B*, Sometimes gully bottoms heal over with grasses and vines when adequately protected from damage from fire and the overgrazing of livestock. The banks, however, may erode away. *C*, A formerly eroding field now fully held by a stand of elm trees that came up voluntarily.

HEALING GULLIES WITH TREES, VINES, AND GRASSES

THE FIRST STEP—BUILD CHECK DAMS

Brush if laid compactly and staked will stop downward cutting and catch up topsoil in which the trees or grass, or both, are to be planted. Dams should slope downward to a low place in the middle and seldom be higher than 2 feet at that point. The purpose is not to fill up the gully, but to make it possible to heal the surface. The dams are only temporary in character, good for 3 to 6 years, or until the trees or grass can get a good start.

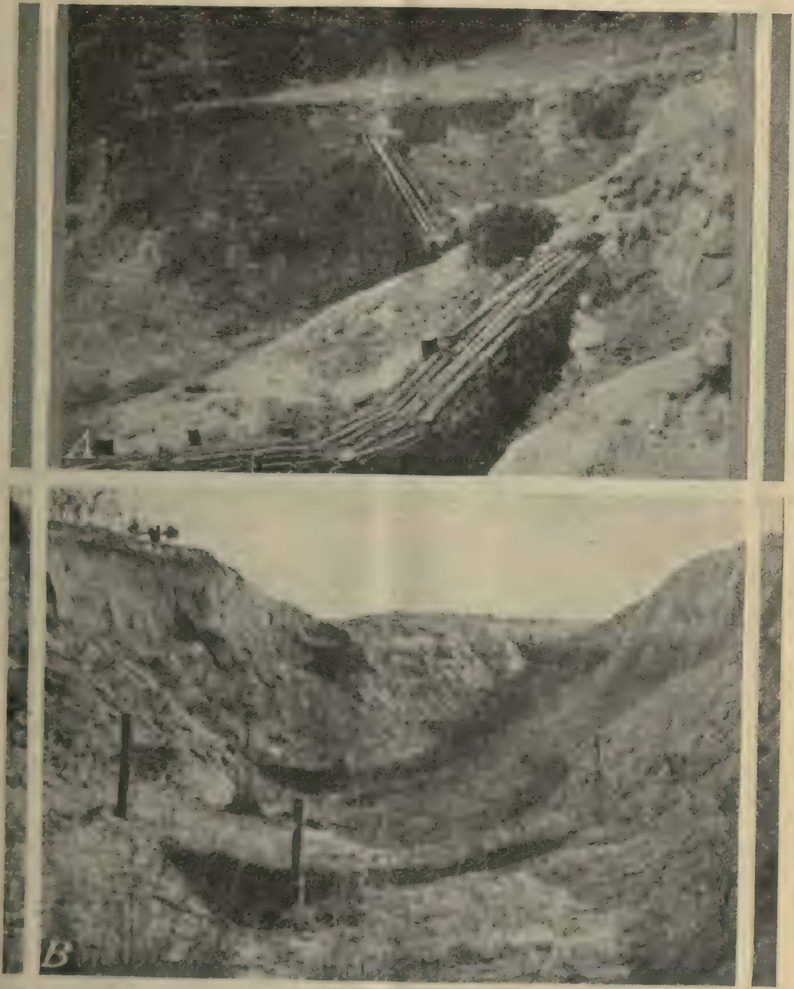

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FIGURE 6.—*A*, Check dam of densely packed brush with straw at the bottom and a layer of small poles on top bound down with wire to upright poles. *B*, Placing low check dams at frequent intervals is good practice. They will catch and hold loose dirt and topsoil in which to establish trees or other vegetation.

THE SECOND STEP—SLOPE OR GRADE THE BANKS

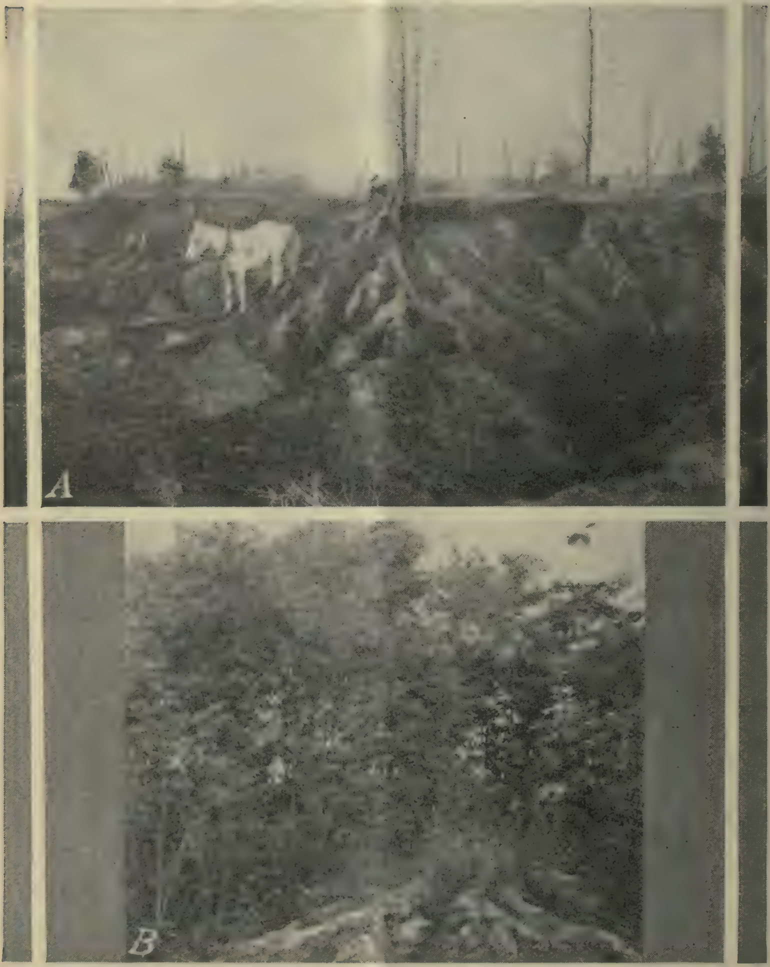

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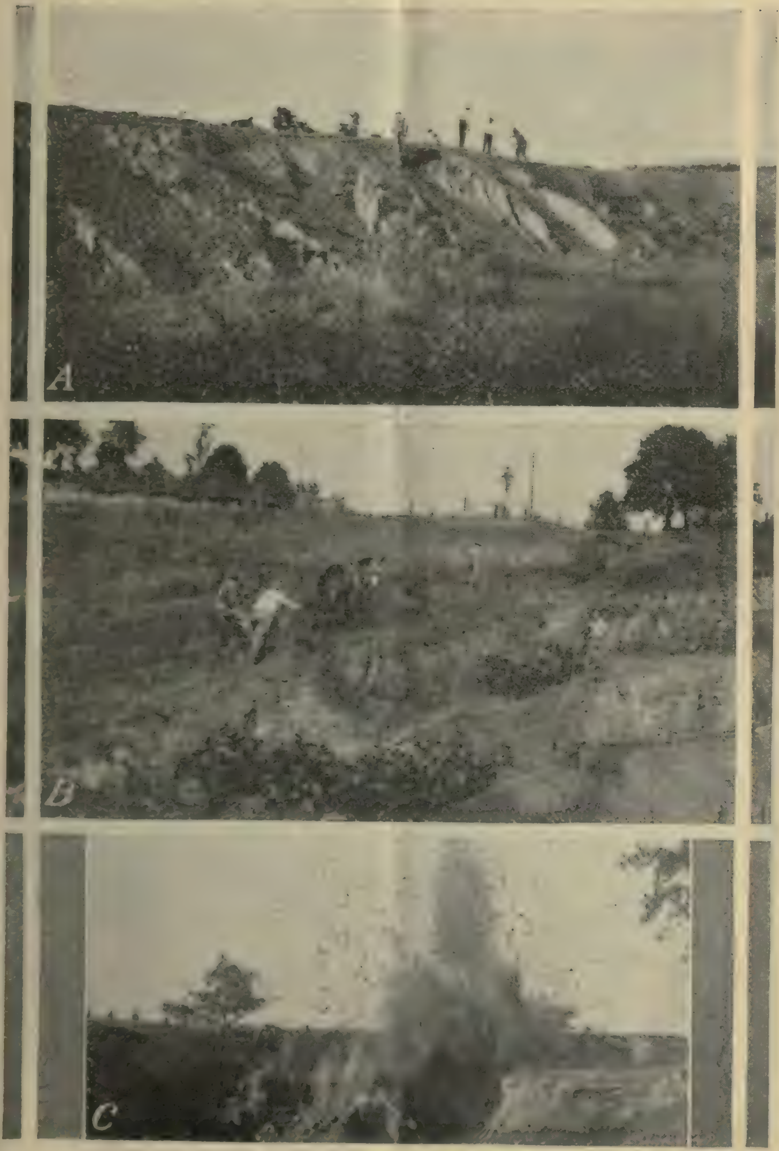
FIGURE 7.—*A*, Plowing down the gully bank to a moderate slope (the angle of repose) loosens the soil and puts topsoil into the gully in preparation for planting the trees and grass. Soil erosion is lessened by sloping the banks. *B*, The same gully fan as that shown in A, a few years after it was plowed down and planted with black locust seedlings.

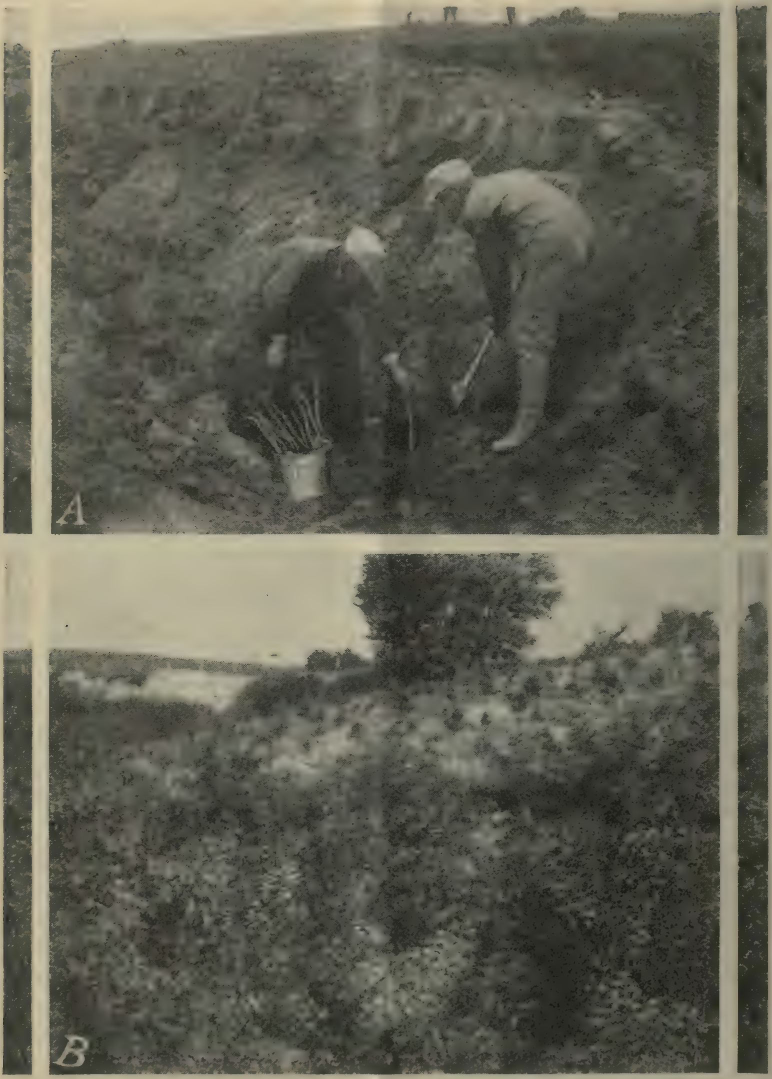
THE SECOND STEP—SLOPE OR GRADE THE BANKS—Continued



F 249792, F 521342, DU PONT POWDER CO.

FIGURE 8.—*A*, Finishing up by hand the sloping off of sharp gully banks; *B*, plowing along the gully margin in preparation for planting a strip of trees from 10 to 30 feet in width; *C*, blasting off the banks of deep gullies by the use of slow-burning powder, as a preparatory step to planting trees or grass.

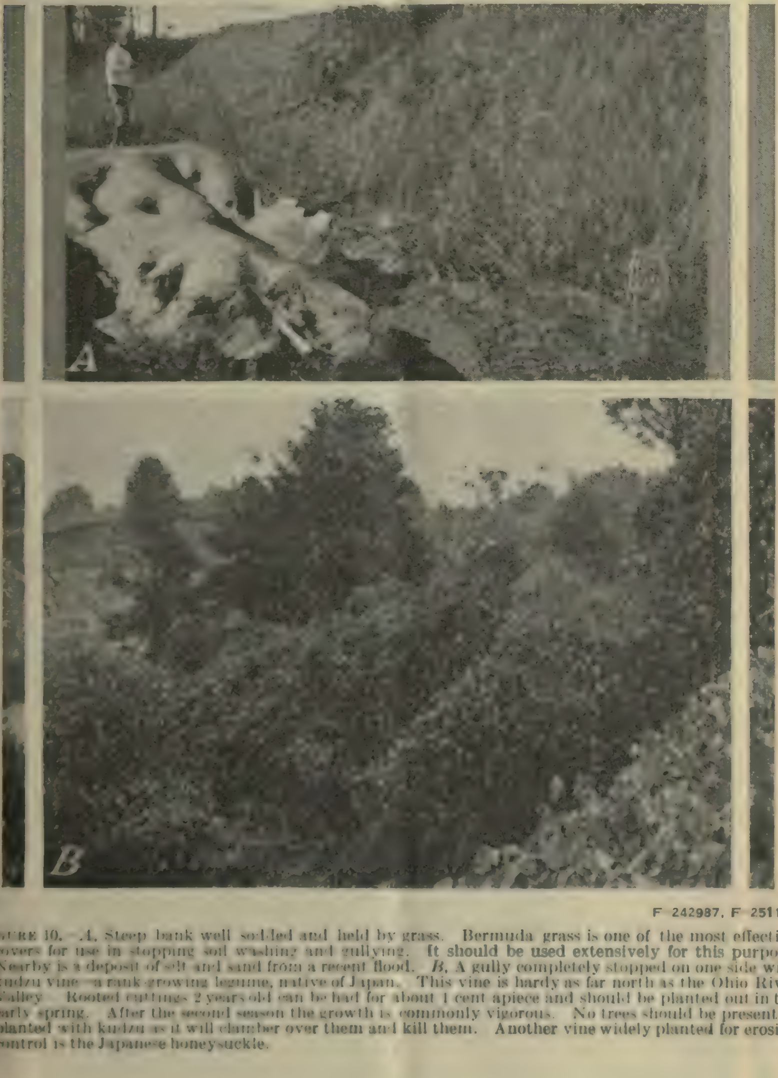
THE THIRD STEP—PLANT TREES, VINES, OR GRASSES



F–284522, F–280185

FIGURE 9.—*A*, Planting a farm gully with tree seedlings. One man digs the holes, and the other follows independently (not as shown) and plants the small trees, carrying them in a bucket with water. A grub hoe is a good tool to use, also a mattock, and in loose soil a dibble or planting iron. *B*, Good planting practice. Pines on the driest ridges, black locust over the main portion of the gully, and willows in the wet and silting gully bottoms. This is regarded as about the most satisfactory combination of trees for such planting and is being used extensively. In the stronger soils the pines are not so essential, while in the poorest soils they and red cedar should be given greater preference.

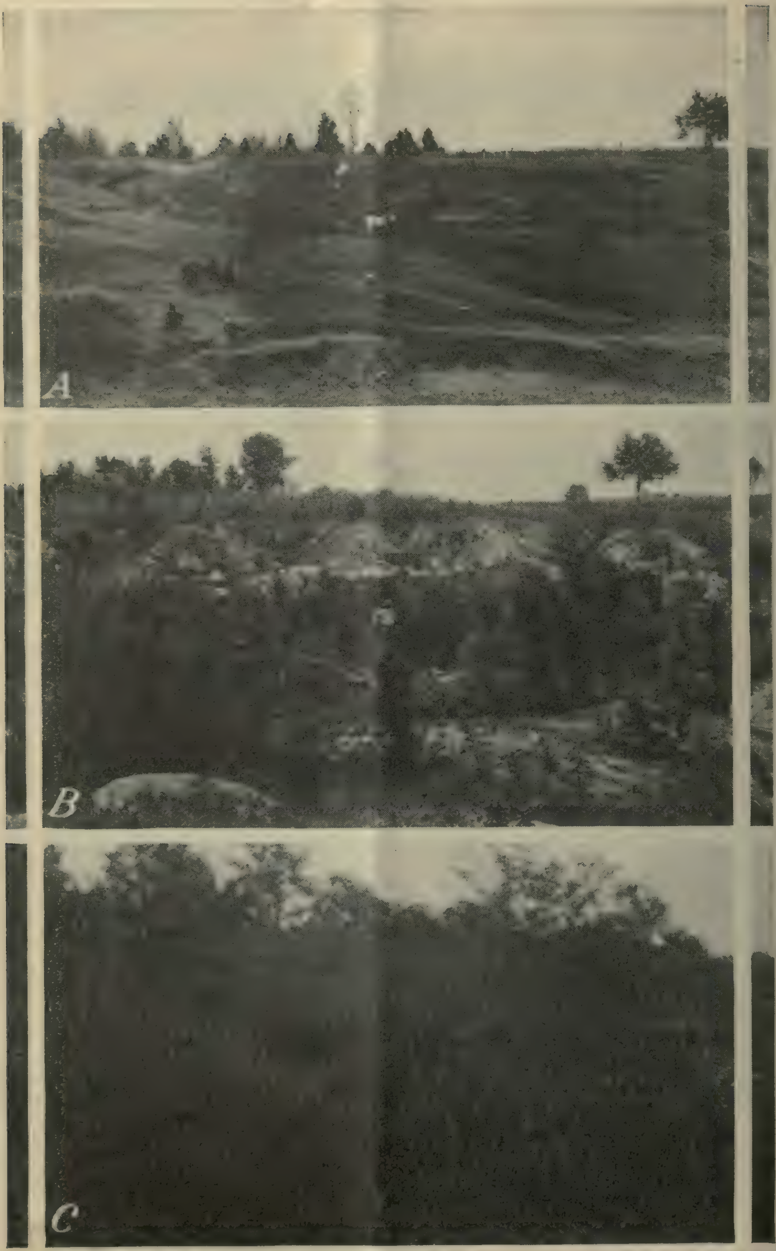
THE FOURTH STEP—PROTECT TREES AND OTHER VEGETATIVE GROWTH FROM INJURY



F 242987, F 251176

FIGURE 10.—*A*, Steep bank well sodded and held by grass. Bermuda grass is one of the most effective covers for use in stopping soil washing and gullying. It should be used extensively for this purpose. Nearby is a deposit of silt and sand from a recent flood. *B*, A gully completely stopped on one side with kudzu vine—a rank-growing legume, native of Japan. This vine is hardy as far north as the Ohio River Valley. Rooted cuttings 2 years old can be had for about 1 cent apiece and should be planted out in the early spring. After the second season the growth is commonly vigorous. No trees should be present or planted with kudzu as it will clamber over them and kill them. Another vine widely planted for erosion control is the Japanese honeysuckle.

PROGRESSIVE HEALING OF A GULLY



TENNESSEE FOREST SERVICE

FIGURE 11.—*A*, Gully which for many years had been widening at the expense of the adjacent fields. Building check dams and plowing in the fall of 1918 in preparation for tree planting in the spring of 1919 (western Tennessee). *B*, How the same gully looked 2 years later. It was planted with black locust seedlings. *C*, How the gully looked 10 years after it was planted. The trees now completely cover the gully, controlling further erosion and turning a liability into an asset.

SOME GULLIES HEALED BY PLANTED TREES

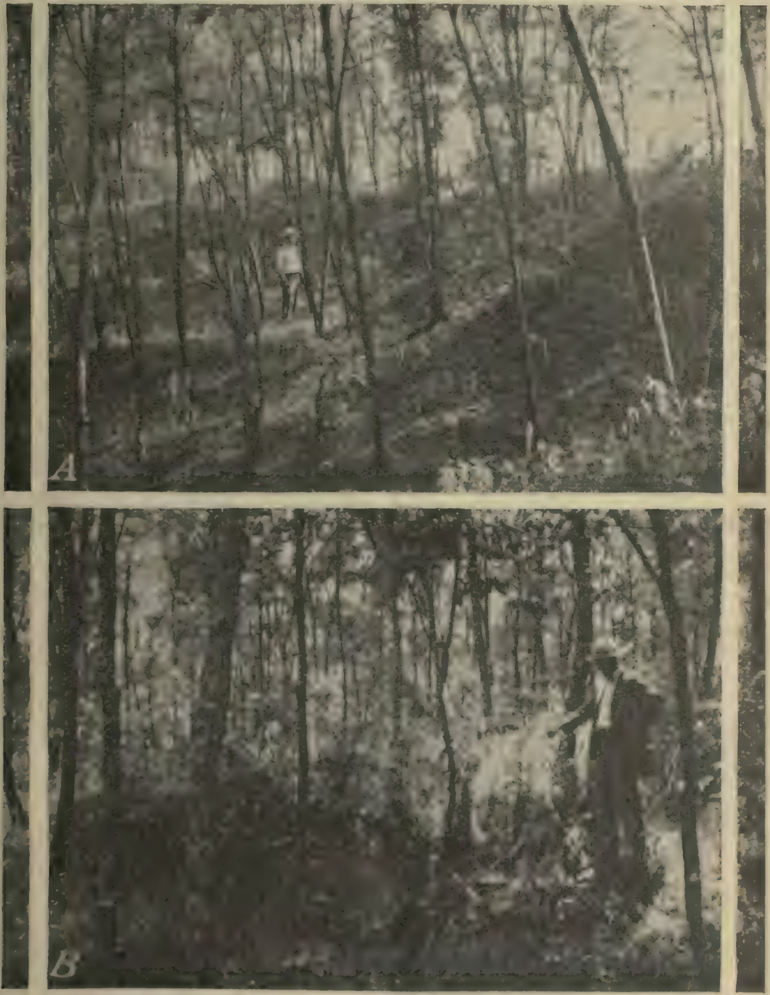


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FIGURE 12.—*A*, Twelve years ago this was an active gully eating rapidly into good cotton fields in western Tennessee. Check dams were built, the banks sloped off, and black locust seedlings planted. The trees are valuable for posts, and bluegrass grows well under them. *B*, In this thrifty stand of black locust trees the man is pointing to one of the brush dams that was built 15 years ago when the gully was treated and planted with trees. The gully is now completely healed.

WRITE FOR COMPLETE INFORMATION

This publication is intended to be merely suggestive of a way in which gullies may be checked. More complete information, including where to get trees and how to plant them, may be had by consulting your local agricultural county agent, who is a representative of the State college of agriculture, your State forestry department, which is probably located at the State capital city, or the Forest Service, United States Department of Agriculture, Washington, D.C. Any of these agencies will be glad also to furnish information with regard to getting up programs for schools or community meetings, lending pictures, lantern slides, film strips, or motion pictures.

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U. S. DEPARTMENT OF AGRICULTURE
FARMERS' BULLETIN No. 1738

FARMHOUSE PLANS

THE FARMHOUSE PLANS presented in this bulletin were developed in connection with the Farm Housing Survey made in the spring of 1934 by the United States Department of Agriculture and the agricultural colleges of 46 States, with funds provided by the Civil Works Administration. These plans were selected from more than 100 prepared under the cooperation of the following agencies and persons:

United States Department of Agriculture: Bureau of Agricultural Engineering, S. H. McCrory, Chief; Bureau of Home Economics, Louise Stanley, Chief, and Director of the Rural Housing Survey.

Alabama Polytechnic Institute: J. B. Wilson, extension engineer, department of agricultural engineering.

University of Arkansas: Deane G. Carter, head, department of agricultural engineering.

University of California: H. B. Walker, head, division of agricultural engineering.

University of Georgia: R. H. Driftmier, professor of agricultural engineering.

University of Illinois: E. W. Lehmann, head, and W. A. Foster, assistant chief in rural architecture, department of agricultural engineering.

Purdue University (Indiana): William Aitkenhead, head, department of agricultural engineering.

Iowa State College: Henry Giese, professor, department of agricultural engineering.

Kansas State Agricultural College: H. E. Wichers, rural architect, department of architecture.

Massachusetts Agricultural College: C. I. Gunness, head, department of agricultural engineering.

University of Minnesota: H. B. White, assistant professor, division of agricultural engineering.

University of Missouri: J. C. Wooley, chairman, department of agricultural engineering.

Ohio State University: R. C. Miller, professor, department of agricultural engineering.

Agricultural and Mechanical College of Texas: D. Scoates, head, department of agricultural engineering.

Virginia Polytechnic Institute: C. E. Seitz, head, department of agricultural engineering.

State College of Washington: L. J. Smith, head, department of agricultural engineering.

University of Wisconsin: S. A. Witzel, extension instructor, department of agricultural engineering.

At each of the cooperating institutions, home economics specialists were consulted by the designers in regard to the arrangement of the kitchen and other parts of the home.

Working drawings for building the houses shown in this bulletin are available from the extension services of the State agricultural colleges. In most cases a small charge is made for the drawings.

Washington, D.C.

Issued October 1934
Slightly revised March 1935

FARMHOUSE PLANS

By WALLACE ASHBY, *Chief, Division of Structures, Bureau of Agricultural Engineering*[1]

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THE PRINCIPAL PURPOSE of this bulletin is to supply plans for low-cost farm dwellings designed to meet the requirements of the farm operator and his family. Some of the plans may be useful in cases where, in addition to the main dwelling, smaller homes are needed for relatives, tenants, or unmarried farm hands. Still others will be found useful in the construction of low-cost houses for temporary use.

A well-built farmhouse should last for 60 years or more. In the ordinary course of events at least two generations of children will be brought up in it. During these years the family operating the farm probably will have no other choice of dwelling. The builder should, therefore, think both of present needs and possible future requirements when selecting a plan for a new farmhouse.

FARMHOUSE REQUIREMENTS

SIZE

The first requirement of a satisfactory farmhouse is adequate size to provide needed working area, storage space, and living and sleeping quarters. For the average family at least three sleeping rooms are needed,[2] one for the parents, one for the boys, and one for the girls.

All the space may not be needed at the time the house is built, but the chances are that it will be needed before many years. On the other hand, many families find that after the children have grown up and left home it is not necessary to use the entire house. For this reason it is desirable to have it arranged so that part of the rooms may be closed off or may be rented to tourists.

---

[1] Acknowledgment is made of the extended collaboration of Louise Stanley, Chief, Bureau of Home Economics, in selecting and reviewing the plans presented herein; and of the helpful assistance of W. H. Nash, architect, Bureau of Agricultural Engineering, in the preparation of both the manuscript and illustrations for publication. Mary Rokahr, senior home management specialist, Extension Service, and Eloise Davison, director of domestic electric service program, Electric Home and Farm Authority, made valuable suggestions regarding arrangement of kitchens and other equipment. Helpful comments and suggestions have been received from many other persons. Many of the perspective sketches illustrating the house plans shown in this bulletin were drawn by C. W. Mead, Bureau of Agricultural Engineering.

[2] Sometimes the living room must serve as one of the sleeping rooms.

COMFORT AND CONVENIENCE

Adequate, well-used space for both the family and the furniture is a large factor in farmhouse comfort. The proper number, size, and placement of windows, doors, and stairs, and good construction are important. These matters have been carefully worked out in the plans shown in this bulletin. Comfort also depends to a large extent on good heating, plumbing, lighting, and screening. Information on some of these subjects is given in Farmers' Bulletin 1698, Heating the Farm Home; 1448, Farmstead Water Supply; 1426, Farm Plumbing; 1227, Sewage and Sewerage of Farm Homes; Department Circular 405, The Domestic Oil Burner; and in U.S. Department of Commerce bulletin, Insulation on the Farm, price 10 cents.

The convenient arrangement of the farmhouse begins with its relationship to the other farm buildings and to the highway. Unlike the city house, the farmhouse has its main line of communication through the back or side door. Therefore outside doors and porches should be located so as to give convenient entrance from the farm driveway and the path to the barn, and wherever possible should be on the sheltered side of the house.

If possible, there should be a convenient place near the rear entrance for men to leave their outer wraps and to wash before going into the house. These facilities are often provided in a washroom or in one corner of the workroom, but if there is no washroom or workroom in the house, there should at least be clothes hooks and a bench and washbasin for summer use on the back porch.

It is also desirable that the work portions of the house, where the housewife spends much of her time, look out over the farm buildings and the entrance roadway. Most farm women like also a glimpse of the highway from the kitchen window.

Preferably the traffic way from the rear entrance to the main portion of the house should not lead through the kitchen. If the kitchen must be used as a passageway, the doors should be so arranged that the traffic does not cross the work area. This not only decreases the possibility of interference with household activities but also makes possible a more compact and convenient arrangement of work equipment. An important factor is a workroom or porch, on about the same level as the kitchen, for laundry, canning, care of milk, and other farm activities and for supplementary food storage. This saves much clutter in the kitchen itself and contributes to more efficient arrangement.

At least one bedroom should be provided on the first floor of the farmhouse, not too far from the kitchen, so that small children or sick persons may be cared for conveniently. The bathroom should be convenient to both downstairs and upstairs bedrooms, but preferably on the first floor. A space for a bathroom is very desirable even if the fixtures cannot be put in at once.

Ample storage space should be provided for clothing, bedding and linen, wraps, food, dishes and utensils, cleaning equipment, toys, and fuel. In general, these needs have been met in the plans given in this bulletin by closets in halls and bedrooms, kitchen cabinets, shelves or pantries, and cellar storage. Closet, cabinet, and shelf space adds greatly to the convenience and comfort of a house and should not be omitted.[3]

In the smaller plans shown here, an alcove or an end of the kitchen is indicated for use as a dining area. In the larger plans, either a dining room or a space for dining in the living room is provided, and in most cases there is also space in the kitchen for "hurry-up" meals.

The following points have been kept in mind in planning the kitchens.

A sink in every house is recommended. Even when water must be carried into the house, the sink and drain add much to the convenience of the kitchen and may be installed very cheaply. Where running water is not available, a pump may be installed beside the sink. However, running water, hot and cold, adds more to the convenience of the farm home than almost any other factor.

The sink should be well lighted, with windows over or at one end of it. Windows over the sink should have the sills higher than the back of the sink. Such windows will need to be shielded from sun glare unless on the north side of the house. The sink should have a drain board at the left end, at the right a flat shelf for stacking dishes if there is no drain board there. Dish storage should be near enough the left end of the sink for the dishes to be put away without unnecessary steps.

The cookstove should be conveniently near the sink, preferably against the side wall, or across from it if the kitchen is narrow.

A small food-preparation surface, table or shelf, should be placed next to the stove at the same height as the cooking surface. There should be cupboard space near the stove for the storage of cooking utensils. A worktable should be provided for long mixing jobs; it should have knee space and toe space. Staple supplies should be stored near this table and, if possible, should be near the refrigerator and not too far from the stove.

The refrigerator should, for convenient use, be as near as possible to the worktable and stove; however, the higher the surrounding temperature the greater the cost of operating the refrigerator. If an ice refrigerator is used, a location near the outside door lessens the tracking of dirt into the house. A ventilated cupboard near the worktable is convenient for storing the less perishable foods and reduces the season during which ice is needed.

RELATION TO OTHER BUILDINGS AND HIGHWAY

A house designed for the south or west side of the highway should be reversed if it is to be built on the north or east. For example, plan 6521 (p. 24) would fit nicely on either the south or the west side of the main road. If it were south of the highway, with the drive as shown, the kitchen would be on the east where it would have the advantage of the morning sunlight and in most localities the screened porch would be sheltered from the coldest winds. If the house were on the west side of the road, the kitchen would still get morning sunlight, and the porch would protect it from the afternoon sun. On the other hand, if the house were to be built on the north or east side of the road, the kitchen would be badly sheltered and lighted, but reversing the plan so that the kitchen would be on the right instead of the left side of the house would remedy these conditions.

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[3] Plans for closets and storage spaces can be obtained from the Bureau of Home Economics.

Before deciding to build any house the plan should be studied carefully to see how it will best fit the location and the arrangement of the rest of the farmstead.

APPEARANCE

Attractive appearance of a farmhouse is to be obtained by:

Good taste in its proportions and exterior design.

Materials chosen to suit the local environment and type of house, effectively employed.

A pleasing color scheme for the house, in harmony with its surroundings.

Proper planning with relation to the natural features of the site, the other farm buildings, and the highway.

Grading the site and planting trees, shrubs, and flowers.

If the homes shown in this bulletin are carefully built according to the drawings, they will be satisfactory with respect to the first two points.

Proper location of the house is exceedingly important and must be worked out on the ground. Farmers' Bulletin 1132, Planning the Farmstead, and 1087, Beautifying the Farmstead, will be found helpful in this and in the planting of trees and shrubs around the house. Farmers' Bulletin 1452, Painting on the Farm, discusses kinds and uses of paints. Other bulletins on these subjects are available from several of the State agricultural colleges.

SAFETY

Safety in the farmhouse depends first on good construction for protection from damage by wind, fire, decay, and termites. Safety is promoted also by planning to avoid hazards from low beams, steep or unguarded stairways, or badly placed doors and windows. The working drawings for the houses illustrated herein embody good practice in these matters. The welfare and convenience of the occupants will be further permanently safeguarded through rat-proof construction, which eliminates " rat harbors ", and denies easy entrance of the rodents to the building. Additional safety may be secured at slight cost by following the recommendations in Farmers' Bulletins 1590, Fire Protective Construction on the Farm; 1638, Rat Proofing Buildings and Premises; and 1649, Construction of Chimneys and Fireplaces; Leaflet 87, Wind-Resistant Construction for Farm Buildings, and Leaflet 101, Injury to Buildings by Termites.

CONSTRUCTION MATERIALS

The houses shown in this bulletin may, with slight changes, be built of wood, stone, concrete, brick, tile, earth, steel, or other materials. The choice depends largely on owner's preference, local availability and price, and the skill of local builders in using one or another. Many new materials for various purposes such as roofing, flooring, and insulation are on the market and deserve consideration.

The practice common among farmers of hauling their own stone or concrete materials, cutting their own logs where possible, having their lumber sawed at local mills, and doing part of the actual construction work, aid in reducing the cash cutlay and in making possible a better house for the same money expenditure. This is especially true where lumber is sawed long enough before building starts to allow thorough seasoning. This seasoning of lumber is important and is too often disregarded.

COSTS

The most satisfactory way to learn the probable cost of a house is to obtain estimates from one or more local builders. Approximate costs may, of course, be obtained by comparing the proposed house with one built recently in the same community, or rough estimates may be based on the size of the house and typical unit costs for the locality.

Unit costs based on prices and wages prevailing in the spring of 1934 for houses suitable for the localities were obtained for about 300 counties by the Farm Housing Survey. A summary of the figures is as follows:

CELLARS

Costs for ordinary cellars were reported for most sections as varying from 50 cents to $1 per square foot of floor space. The cost per square foot is, of course, less for a large than for a small cellar, other things being equal. Easy excavation and low-cost materials also make for low unit cost. Costs of nearly $2 per square foot were reported in some sections where the ground-water level is high and cellar walls and floor must be carefully waterproofed. In sections where cellars are not ordinarily used the cost of the foundation was reported as part of the cost of the house superstructure.

SUPERSTRUCTURES AND PORCHES

Reported costs of one-story frame superstructures, including heating, plumbing, and lighting equipment ordinarily used in the locality, ranged from $1.25 to $2.25 per square foot of floor space in the South, from $2.25 to $3.50 in the West and Southwest, from $2.50 to $4 in the North, and from $3 to $4.50 in New England. Costs in Maryland, Virginia, and West Virginia and in a narrow belt along the east coast, including Florida, were reported from $2 to $3.25, and in the timber-producing sections of the Northwest at about $2 per square foot. Costs in any locality are influenced by local factors, generally being relatively high near cities and in thickly settled sections and relatively low in places where there are local supplies of lumber or other materials.

Differences in cost between the various sections are due to differences in the kinds of houses built, as well as to differences in material costs and wages. The typical house in the North is much more compact and substantial and provided with more expensive heating equipment than the typical house in the South.

The cost per square foot of floor area of two-story frame houses was reported as being 5 to 15 percent less than that of one-story houses in the same locality.

The costs of typical masonry superstructures were generally reported at $2 to $3 per square foot of floor area in the southern third of the United States, from $3 to $4 per square foot in the central third, and more than $4 per square foot in the northern third of the country. There were many variations from these general levels, however, costs of about $2 per square foot being reported in many localities in the States bordering on or south of the Ohio River. Costs reported for counties along the Atlantic and Gulf coasts were generally higher than for those in the interior. Little difference in cost per square foot of floor area in one-story and in two-story masonry houses was reported. The higher costs reported for masonry houses as compared with frame are probably due in part to better grades of finish and equipment used in the masonry houses.

The costs per square foot of floor space of open porches were reported as being about half the costs per square foot of floor space in one-story houses of similar materials.

ESTIMATING BY UNIT COSTS

The floor areas of the cellar, the porches, and the house itself (the superstructure) are shown with each plan. They do not include unexcavated cellar space nor unfinished space in attics. The areas were figured from the working drawings (see p. 7) because in some cases the dimensions given in the plans herein are approximate only. The superstructure area of a house of more than one story is given here as the area of the first floor plus the usable area of the second floor. Stairways, halls, and closets are included. To estimate very roughly what a house might cost, multiply the number of square feet of cellar floor space by a cost per square foot based on the costs stated above. Do the same for the house superstructure and the porches, and add the figures together. This, with allowance for price changes since the spring of 1934, will give a rough estimate of total cost of the house. The actual cost will, of course, be affected by the materials and home equipment which the owner selects and by the skill and efficiency of the builders.

If the owner can furnish part of the material or labor, or if interior finish or equipment is omitted, the initial cash outlay may be reduced. Estimates based on local prices and wage rates are to be preferred to those based on the cost figures given above.

Little study has been given to what amounts farm people are justified in spending for their houses, but several investigations have been made of expenditures for housing by people with fixed incomes. It is generally agreed that the house ordinarily should not cost more than two and one-half times the average annual net income of the family. In the case of the farm family the value of the living furnished by the farm should be considered as part of the income. Another generally accepted rule, which perhaps is more nearly applicable to farm conditions, is that not more than 25 percent—usually not more than 20 percent—of the average annual net income of the family should be required for housing, including principal payments, interest, taxes, insurance, repairs, and miscellaneous costs.

WORKING DRAWINGS

Working drawings have been prepared giving all necessary dimensions and details for building these homes. Farmers may obtain copies of these drawings from the agricultural extension services of the State agricultural colleges. The State extension services will supply only those plans which are suitable in their respective States, and usually will make a small charge to cover printing and mailing.

CAUTION REGARDING CHANGES

These plans have been carefully prepared by competent architects in consultation with home-management specialists and agricultural engineers familiar with farm conditions in all parts of the United States. It is urged that the plans be studied carefully before making a selection, but that no changes be made in them except for alternate arrangements indicated by the drawings or descriptions. Changing the size of a room or the location of a door or window may spoil some other valuable feature, and is almost certain to harm the appearance of the house. Doors and windows should be selected according to the descriptive material on the drawings. Sizes should be closely adhered to for best appearance.

The prospective builder should not try to obtain too much originality, but rather should base his selection on those features of the plan which will give the utmost satisfaction in the long run. Differences in slope of ground, location of the drive and farm buildings, and position and amount of trees and shrubbery, all will contribute to the distinctive appearance of the home.

For homes of the type offered in this bulletin, the surroundings should be kept free from distracting adornments. As a general rule, a few trees to provide shade, some flowering shrubs of native growth grouped close to the building to break harsh lines, and a bed or two of flowers selected for their color value, will be sufficient decorative relief.

PLANS FOR HOUSES

The 40 house plans shown in this bulletin have been arranged in four groups representing, respectively, (1) 1-story growing houses; (2) 1-story houses originally built with two or more separate bedrooms; (3) houses of 1½ or 2 stories; and (4) very small houses. Some of the plans might have been placed in another group about as well as in that in which they are shown.

ONE-STORY GROWING HOUSES

There are many arguments in favor of the growing house for the farm. The first unit can be erected at a moderate cost, yet the finished house may have all the features considered important. As more space is needed the owner often can build the additions himself, taking advantage of slack times to cut lumber from his own land, haul sand and gravel for concrete, and in other ways reduce the cost of the additions. The chief difficulty with the growing house is that it is likely to grow very slowly. By the time additions are made the house is considered old by its occupants, and the additions are likely not to receive as careful attention as the original house.

The growing houses in this bulletin have been carefully planned so that both the first units and the final structure are satisfactory in usefulness and in appearance. The additions fit into the original units with a minimum of ripping out and rearrangement.

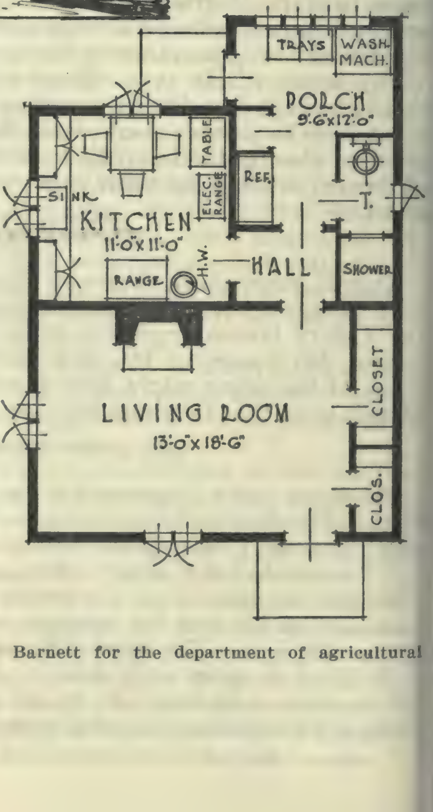
PLAN 6511,[4] FOR THE SOUTHWEST

Floor areas: Superstructure, first unit 605 square feet; with 1-bedroom addition 815 square feet; with 2-bedroom addition 960 square feet.

This plan is for a permanent dwelling of frame, stucco, stone, adobe, or other construction. If desired, the first unit may be built without bedrooms, as shown, and the living room used for sleeping quarters until the house is completed. The two large closets of this living room add much to its value, and the arrangement with all doors at one end of the room permits efficient use of the space.

If the first unit is to be used for several years before the bedrooms are added, the small bathroom with shower will be especially desirable. That space must be used for other purposes, however, and the bathroom fixtures moved when one or both bedrooms are added.

An alternate kitchen arrangement suggested by the Bureau of Home Economics for houses in which only an oil, gas, or electric stove is needed and meals will usually be eaten in the living-dining room is shown on page 9.



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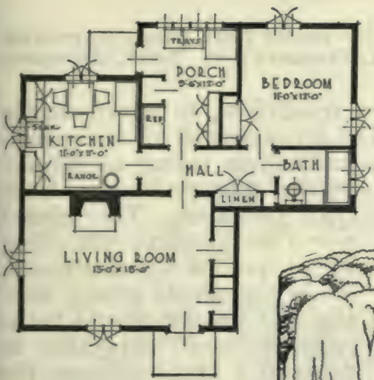
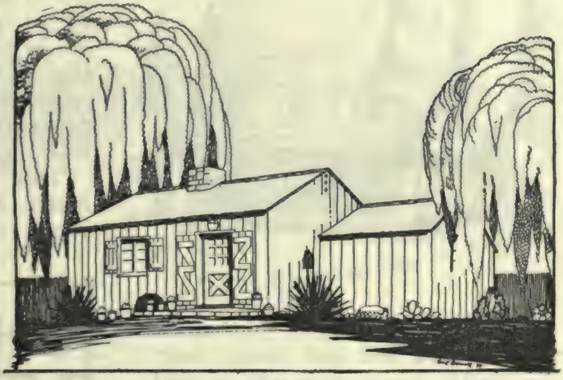
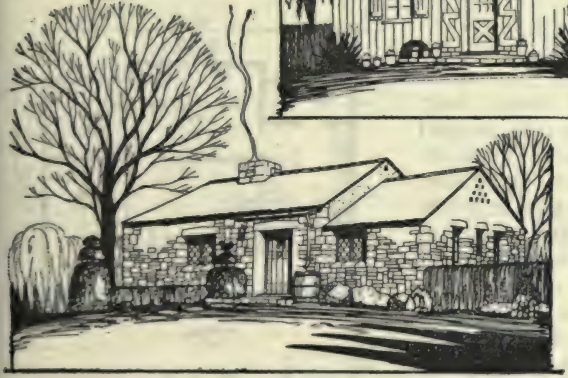
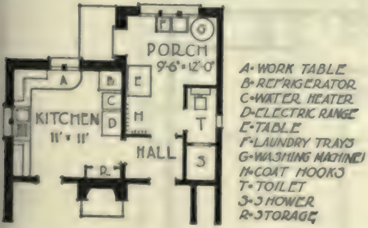
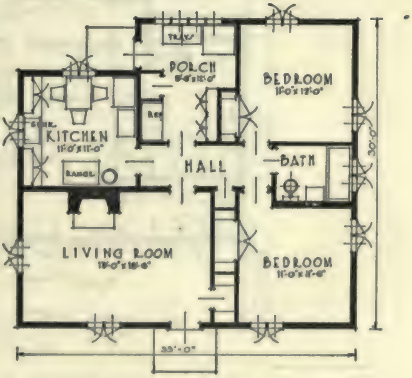
[4] Prepared by W. K. Bartges and Earl Barnett for the department of agricultural engineering, University of California.


TRAYS
PORCH
9'-6"x12'-0"
BEDROOM
11'-0"x12'-0"
SINK
KITCHEN
11'-0"x11'-0"
REF
HALL
BATH
RANGE
LINEN
LIVING ROOM
15'-0"x16'-6"






PORCH
9'-6"x12'-0"
A
B
C
D
E
F
G
H
T
S
R
KITCHEN
11'x11'
HALL
A-WORK TABLE
B-REFRIGERATOR
C-WATER HEATER
D-ELECTRIC RANGE
E-TABLE
F-LAUNDRY TRAYS
G-WASHING MACHINE
H-COAT HOOKS
T-TOILET
S-SHOWER
R-STORAGE

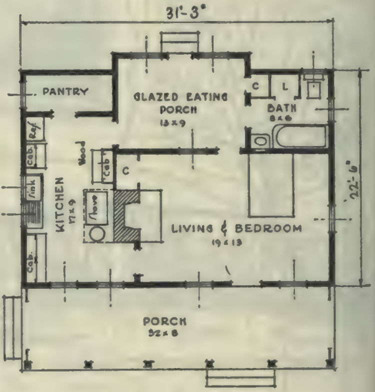

TRAYS
PORCH
9'-6"x12'-0"
BEDROOM
11'-0"x12'-0"
SINK
KITCHEN
11'-0"x11'-0"
REF
RANGE
HALL
BATH
LIVING ROOM
15'-0"x16'-6"
BEDROOM
11'-0"x11'-6"
30'-0"
33'-0"

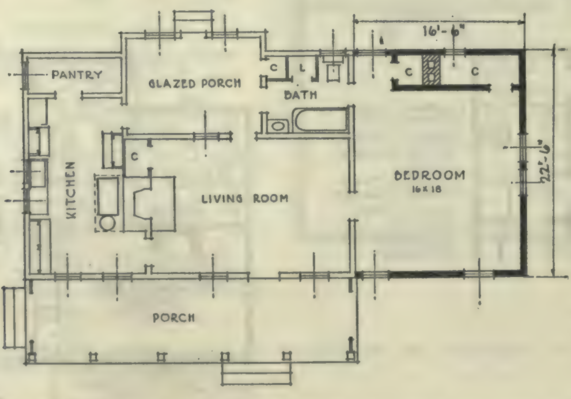
PLAN 6512,[5] FOR THE SOUTH

Floor areas: Superstructure, first stage 715 square feet; second stage with one bedroom 1,085 square feet; third stage 1,515 square feet. Porch, 250 square feet.

Plan 6512 is designed for southern conditions, to afford ample shade from a glaring summer sun. The arrangement of rooms permits the building to face toward the south, thus taking advantage of the summer breezes from that direction. The glazed porch on the north side offers a cool spot for summer meals, while the meals served during cold weather would naturally be more enjoyable in front of a blazing fire at the west end of the living room.

The second stage of the house adds the center bedroom of the three shown in the third stage. The partitions for the hall and the closets near the south porch are not needed until the third stage. If at all possible, the center bedroom should be built with the original unit to provide more sleeping space; but if it is necessary to watch the budget closely, the large living room or the glazed porch can be pressed into temporary service as sleeping quarters.





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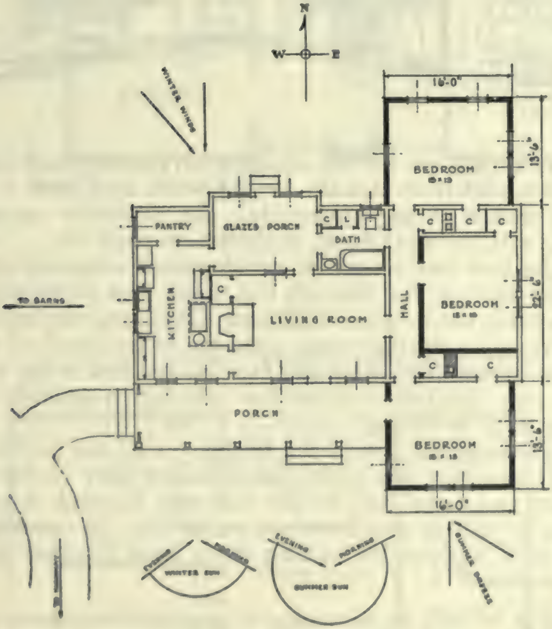
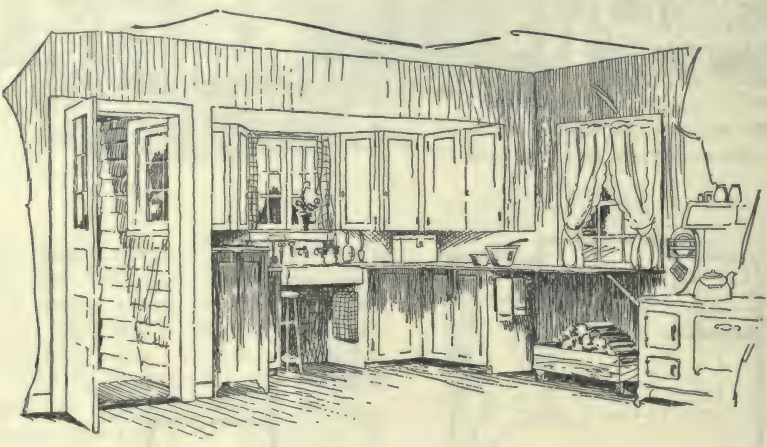
[5] Prepared by J. B. Atkinson and J. E. Hudson for the department of agricultural engineering, Agricultural and Mechanical College of Texas.


N
W
E
WINTER WINDS
16'-0"
13'-6"
BEDROOM
C
C
C
PANTRY
GLAZED PORCH
C
L
BATH
KITCHEN
C
LIVING ROOM
HALL
BEDROOM
22'-6"
TO BARNS
C
C
PORCH
BEDROOM
13'-6"
16'-0"
EVENING
MORNING
WINTER SUN
EVENING
MORNING
SUMMER SUN
SUMMER BREEZES

PLAN 6513,[6] FOR THE SOUTH

Floor areas: Superstructure, first unit 490 square feet; with first addition 705 square feet; completed house 1,015 square feet. Porches, first unit 25 square feet; with first addition 240 square feet.

The first unit of house 6513 is modest, and yet provides complete kitchen equipment, toilet facilities, a workroom or laundry, and a bedroom of comfortable size. The first addition increases the living accommodations and, with its front and rear porches, offers a cool retreat in hot weather. The second addition provides two more bedrooms and an adjoining bath, thus completing the six-room house. If desired, these two bedrooms may be made larger than shown in the plans.



The interior view shows the compact arrangement of kitchen cabinets and sink, and indicates the bright work area that is planned to lighten the duties of the housewife. An alternate arrangement of the kitchen, with no workroom, is shown on page 13.

During the first two stages of development adequate space will be found in the kitchen for dining; but when two bedrooms are added in the final wing, the original bedroom (adjoining the kitchen) might be converted into a dining room. On the other hand, if at times the entire house is not needed by the family, the last wing of the house will make very desirable rooms for renting to tourists or summer boarders, or may be closed.

In some parts of the South the fireplace will not provide sufficient heat in cold weather, but a circulator heater may be set in front of the fireplace and connected to the chimney through a metal shield. If the plan is used in the North, a cellar may be constructed under the second unit, with stairs leading down from the rear porch, which should be enclosed.

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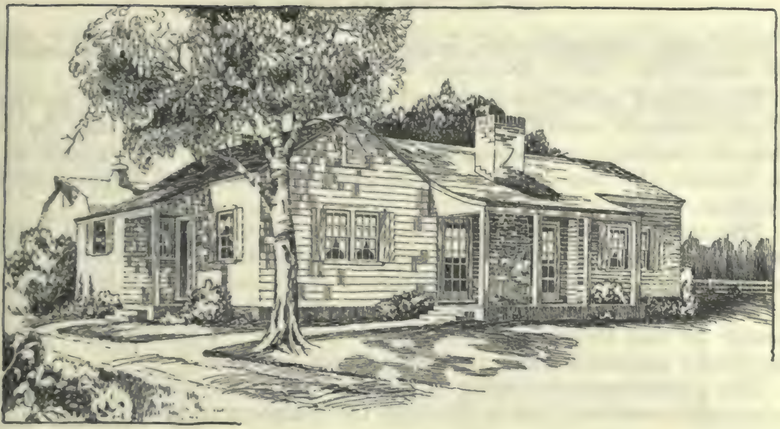
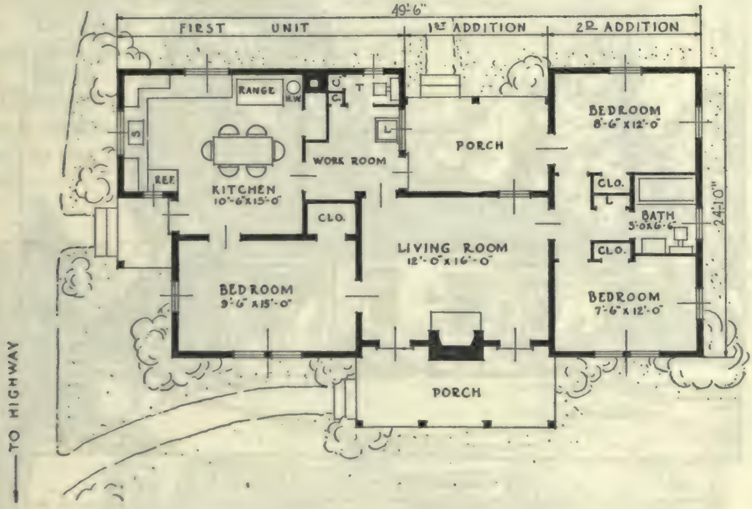
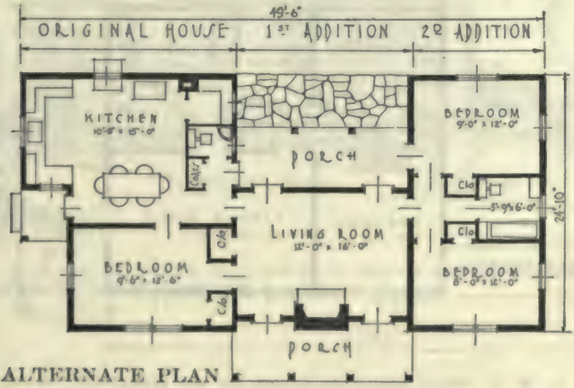
[6] Prepared by W. H. Nash for the Bureaus of Agricultural Engineering and Home Economics, U.S. Department of Agriculture.







ALTERNATE PLAN

PLAN 6514,[7] FOR THE MIDDLE WEST

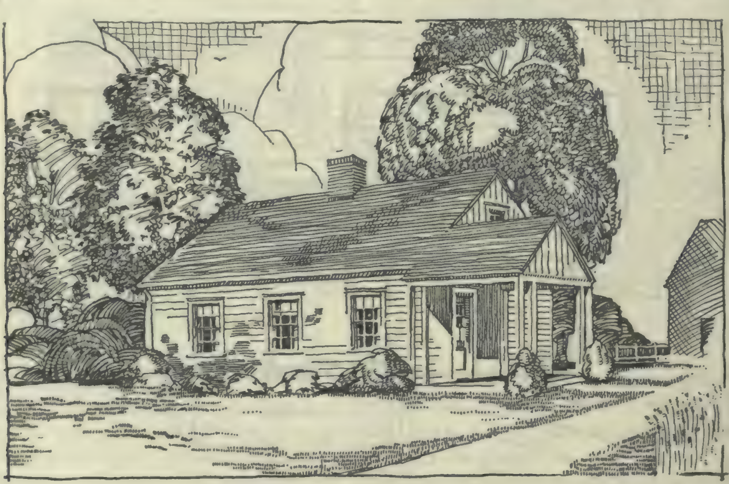
Floor areas: Superstructure, original house 670 square feet; with addition 940 square feet. Cellar, 255 square feet. Porches, 120 square feet.

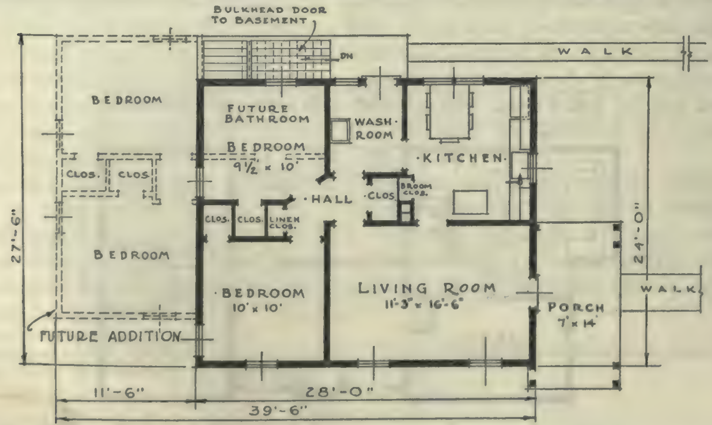
House 6514, with basement and furnace, is well adapted to northern or mid-western conditions. The steps to the basement may be outside the building as shown, or the wash room may be extended so as to include the steps and provide greater protection during stormy weather.

The original house, in order to come in the class of low-cost houses, does not contain a bath. A pump at the kitchen sink provides water until funds permit of the installation of a modern plumbing system.

The first unit of the house may be heated either by a circulator heater in the living room or by a furnace. The furnace will be especially desirable after the second unit is added.

The added bedroom wing is recessed from the main building line to permit cross ventilation through the bedroom in the original house.





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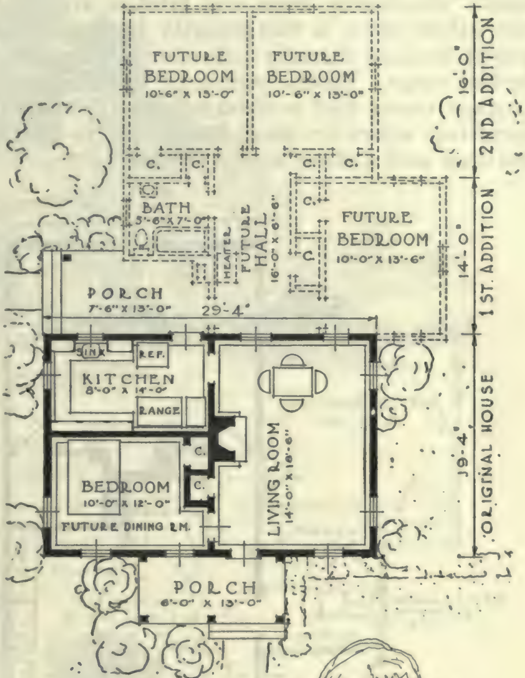
[7] Prepared by W. E. Pettit and Fred Riebel for the department of agricultural engineering, Ohio State University.

PLAN 6515,[8] FOR THE SOUTH

Floor areas: Superstructure, first unit 565 square feet; with first addition 900 square feet; completed house 1,255 square feet. Porches, 175 square feet.

This begins as a three-room house but is planned so that eventually three bedrooms and a bath may be added. The kitchen in the original house is nicely arranged, as shown in the plan. When the house is completed, the first bedroom may be used as a dining room, with a door cut through from the kitchen. The range should then be placed against the living-room wall. The fireplace and range will heat the first three rooms. Hall space for a circulator heater is provided in the first addition.



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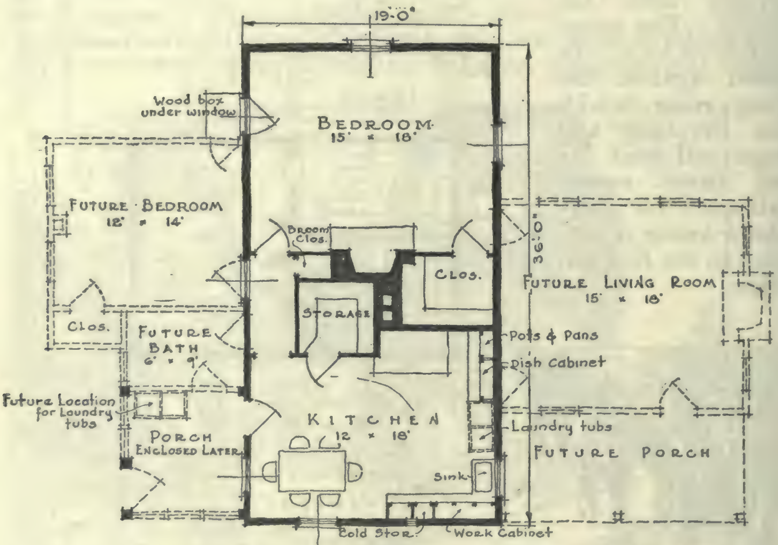
[8] Prepared by C. W. Heery, Fred J. Orr, and B. G. Danner for the department of agricultural engineering, University of Georgia.

PLAN 6516,[9] FOR THE SOUTH

Floor areas: Superstructure, original unit 685 square feet; with first addition 1,035 square feet; completed house 1,345 square feet. Porches, original 90 square feet; completed house 155 square feet.

The original unit of house 6516 is a two-room structure of ample size. The dining room and kitchen are combined in one room, while the other room is temporarily both bedroom and living room. A porch leading directly into the kitchen affords entrance during the initial stage. In the center of the first unit are an unusually large storage closet and a chimney reminiscent of colonial Virginia. In localities where firewood is not readily available the fireplace may be omitted and a stove used for heating the bedroom.



PLAN
Showing Future Additions

Additions to the house are indicated on both sides of the original; the first addition undoubtedly would be that with the bedroom and bath. The rear porch can be enclosed if needed, and will then serve for laundering and other work that is more convenient not to do in the kitchen. The second addition will complete the house with a living room and front porch.

The addition of the living room and front porch requires considerable change in the arrangement of the kitchen to keep traffic from the back door to the living room from passing directly in front of the range. It will be best to set the range against the end wall, and preferably to use an electric or oil range so that no new chimney will be required. After the living room is added, less dining space will be needed in the kitchen.

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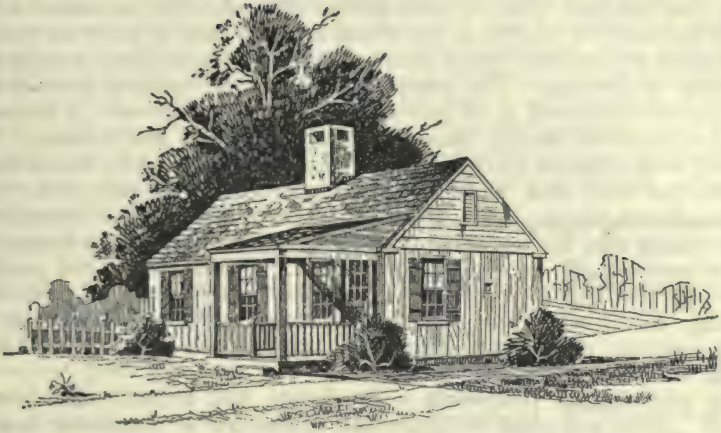
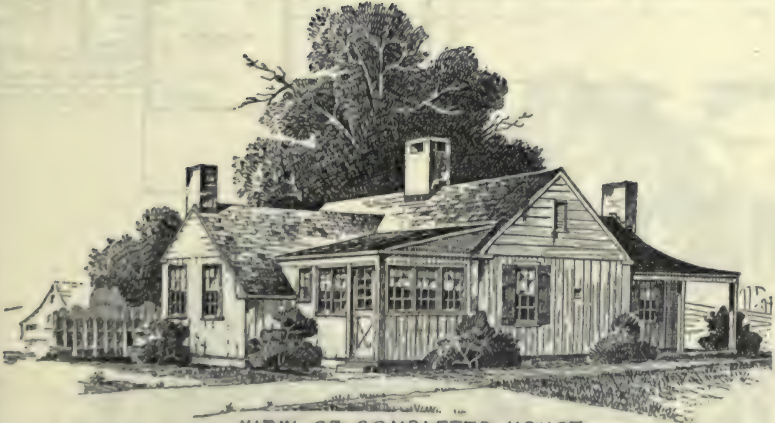
[9] Prepared by H. B. Boynton and J. M. Thompson for the department of agricultural engineering, Virginia Polytechnic Institute.



VIEW OF ORIGINAL UNIT



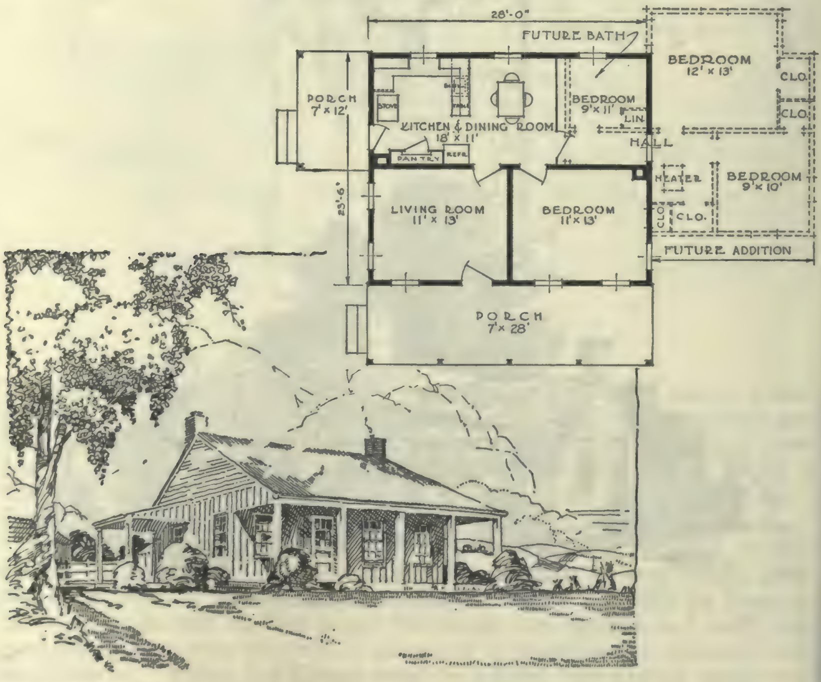
VIEW OF COMPLETED HOUSE

PLAN 6517,[10] FOR THE SOUTH

Floor areas: Superstructure, original house 660 square feet; completed house 1,025 square feet. Porches, 300 square feet.

In plan 6517 a large amount of space is provided at low cost by using the cheapest type of construction and omitting the interior finish at the time of building, for when a large family must be housed and funds are limited space is often more desirable than good finish and ease of heating. The exterior walls are of vertical boards and battens, and the roof is of galvanized corrugated metal. The house may be improved at any time by lining the walls and ceiling. The kitchen arrangement shows a treatment recommended by home economists, the sink and worktable at right angles to the wall, with shelves above them. This scheme has the advantage of separating the working and dining areas, yet it does not hamper easy communication between the rooms at meal hours. If desired, a bed may be placed in the living room, yet the house is so arranged that each sleeping room will have complete privacy. The side wall of the small bedroom next to the kitchen is intended to be made of 1-inch boards with battens on both sides.

The addition of bedrooms with closets and a bathroom is suggested. This addition will provide space for a circulator heater, which is a convenience when no cellar is planned.



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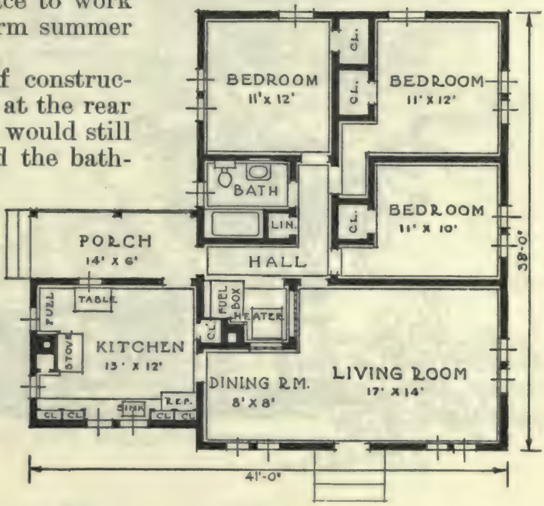
[10] Prepared by the Bureaus of Agricultural Engineering and Home Economics, U.S. Department of Agriculture.

PLAN 6518[11]

Floor areas: Superstructure, first stage 835 square feet; with addition 1,160 square feet. Porches, 120 square feet.

Several novel features about this small dwelling will appeal to the farm-home builder. A heater room on the main floor near the rear entrance and the kitchen avoids the need for a cellar. A kitchen like this, with three outside walls to give light and cross ventilation and a better view of the farmstead and highway, is often desirable. The end of the living room next the kitchen is narrowed to a dining alcove, and when more space is needed the dining table may be extended into the living room. The completed bungalow has three bedrooms, with ample closet space. The rear porch will provide a comfortable, shady place to work outside during the warm summer days.

In the first stage of construction the two bedrooms at the rear may be omitted. This would still leave one bedroom and the bathroom and temporary closet space in the original bungalow. Then the two other bedrooms can be added later, when funds become available, or a screened and glazed sleeping porch with outside entrance could be built instead. A porch off the living room could also be added.



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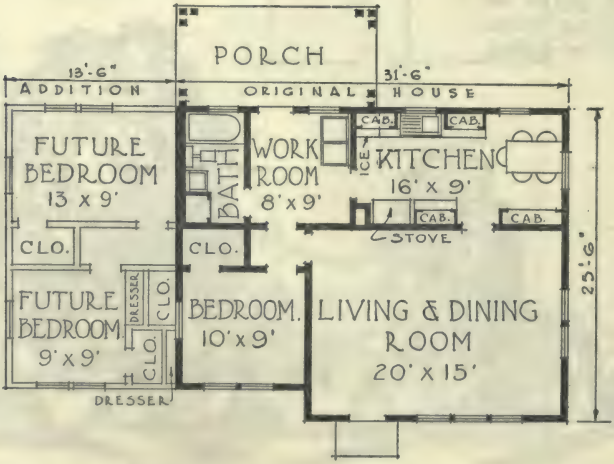
[11] Prepared by L. J. Smith for the department of agricultural engineering, State College of Washington.

PLAN 6519,[12] FOR THE SOUTHWEST

Floor areas: Superstructure, original house 775 square feet; with addition 1,075 square feet. Porches, 160 square feet.

The plans and perspectives on these pages show two methods of roofing this house. In each plan the original unit of the house is complete, and pleasing in appearance, and the additions fit the house gracefully with very little tearing out or rearrangement.

As in some other plans, the kitchen is designed for the use of an oil, gas, or electric cookstove. The house may be heated by a circulator hot-air heater, by a hot-water system with a radiator boiler in



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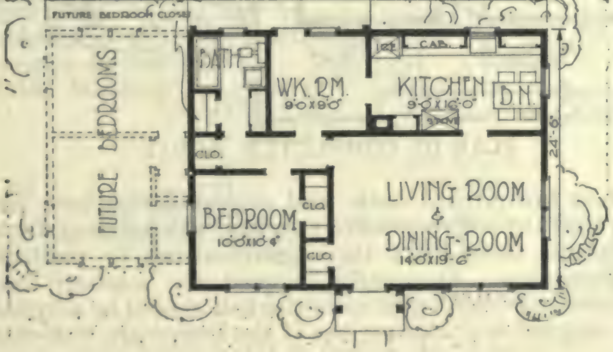
[12] Prepared by H. E. Wichers, O. S. Ekdahl, and N. F. Resch for the department of architecture, Kansas State Agricultural College.

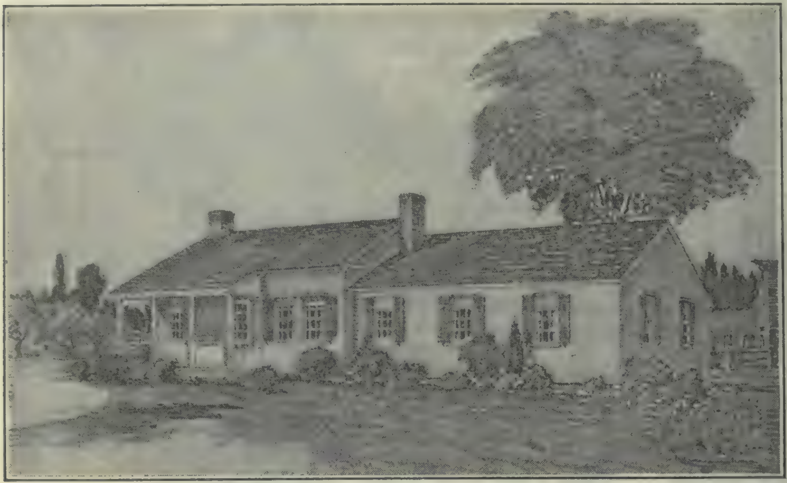
the living room, or possibly by radiant gas or electric heaters in the bedrooms.

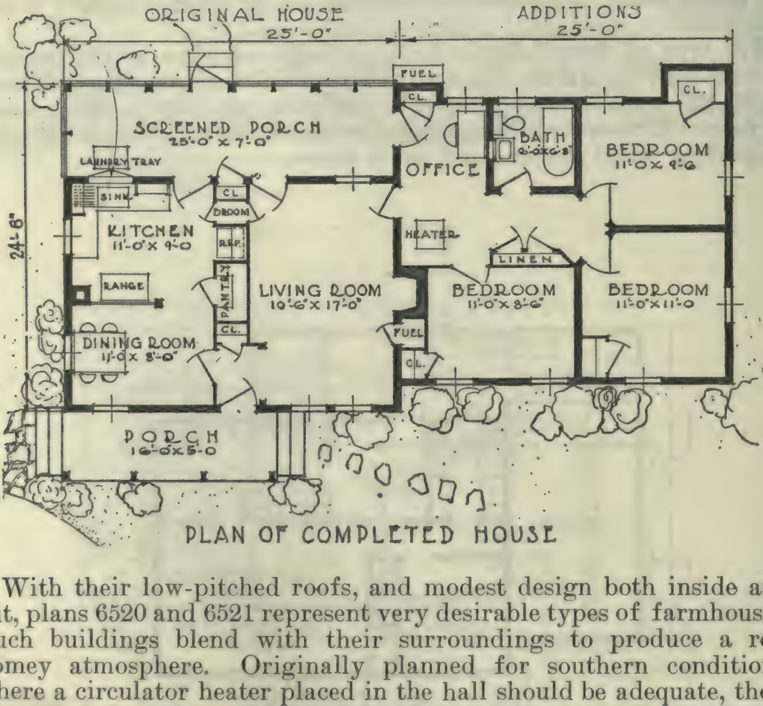
The type of design favors keeping the house close to the ground. If floor-joist construction is used, the topsoil should be removed from under the house so that joists will not come too close to the ground surface. A concrete subfloor could be placed directly on the ground, supporting wood sleepers and wood floors.



PLAN 6520[13]

Floor areas: Superstructure, first unit 450 square feet; with first addition 730 square feet; completed house 985 square feet. Porches, 255 square feet.





PLAN OF COMPLETED HOUSE

With their low-pitched roofs, and modest design both inside and out, plans 6520 and 6521 represent very desirable types of farmhouses. Such buildings blend with their surroundings to produce a real homey atmosphere. Originally planned for southern conditions, where a circulator heater placed in the hall should be adequate, these plans are adapted to colder regions if the houses are well constructed

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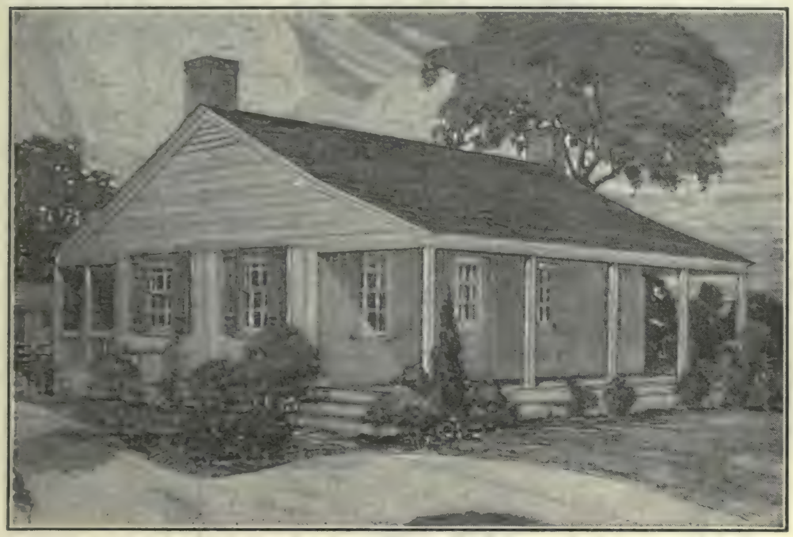
[13] Prepared by Eldred Mowery and C. E. Cope for the Bureaus of Agricultural Engineering and Home Economics, U.S. Department of Agriculture.

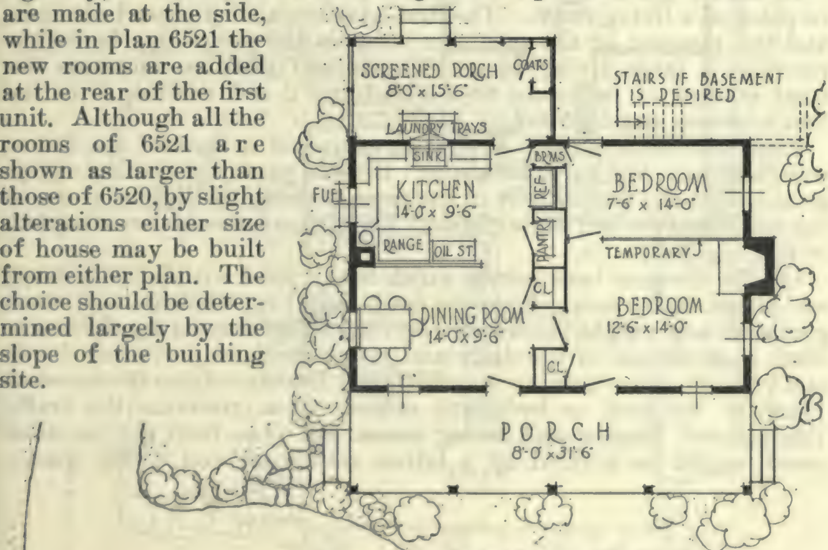
PLAN 6521 [13]

Floor areas: Superstructure, first unit 630 square feet; with first addition 985 square feet; completed house 1,285 square feet. Porches, 385 square feet.



and are provided with basements and central heating plants as indicated on the working drawings.

In both designs the development from two large rooms progresses logically, the main difference being that in plan 6520 the additions are made at the side, while in plan 6521 the new rooms are added at the rear of the first unit. Although all the rooms of 6521 are shown as larger than those of 6520, by slight alterations either size of house may be built from either plan. The choice should be determined largely by the slope of the building site.



FLOOR PLAN OF FIRST UNIT

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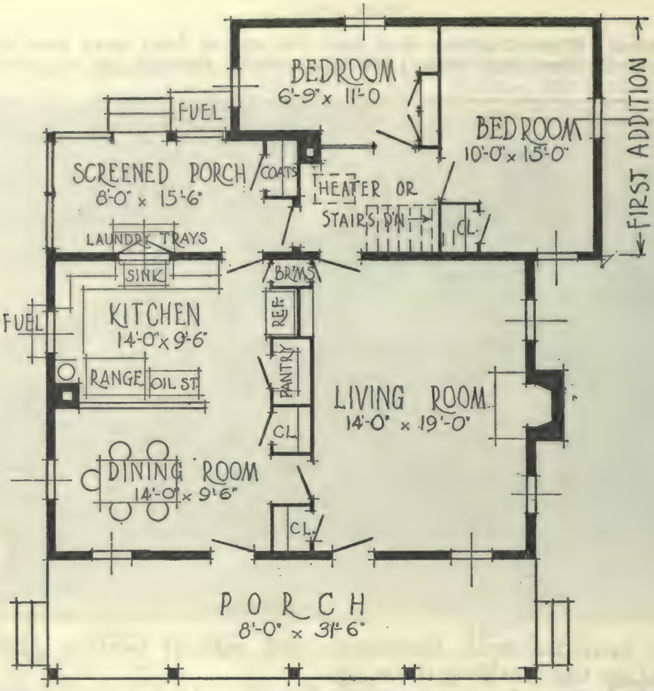
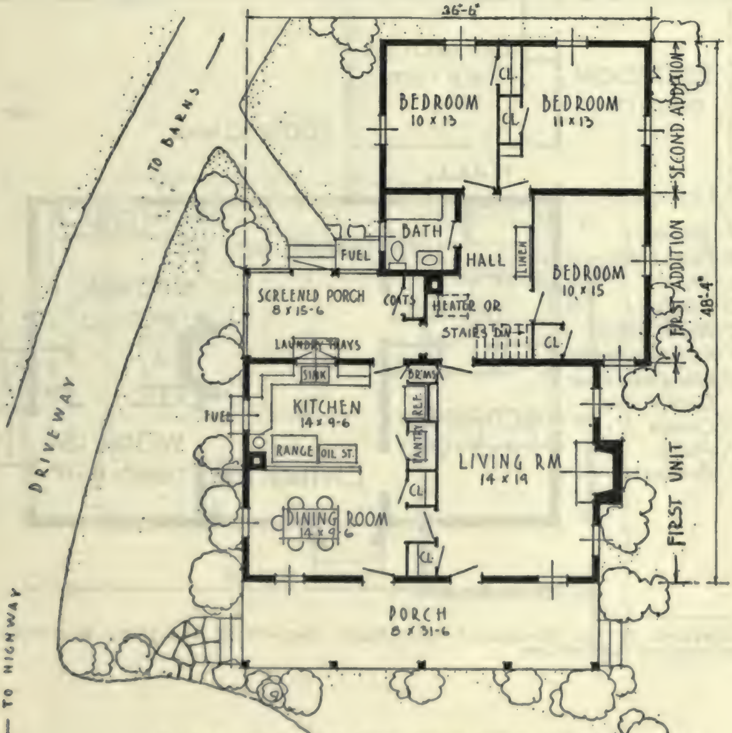
[13] Prepared by Eldred Mowery and C. E. Cope for the Bureaus of Agricultural Engineering and Home Economics, U.S. Department of Agriculture.



In each original house a temporary partition provides 2 bedrooms in place of a living room. The first addition adds 2 other bedrooms, and the removal of the partition between the temporary bedrooms provides a large living room. The second addition increases the total number of bedrooms to 3 by adding 2 and refitting 1 in the first addition as a bathroom.

Each kitchen is ideally located to command a view of the driveway, highway, and farm buildings. Closets, pantry, and other equipment utilize the darker part of the room, leaving the lighter portions for working area and dining table. These arrangements are complete in the original house.

On the screened back porch, which is equipped with laundry trays and closet, men coming from the fields may hang their outside work garments and, except in cold weather, wash before entering the house. Here a great deal of the dirty and messy work in preparing fruits and vegetables for canning may be done. Entrance from the screened porch to the bath or bedrooms reduces to a minimum the traffic through the kitchen and living room. In plan 6520 the screened porch might be divided by a lattice into work and living spaces.



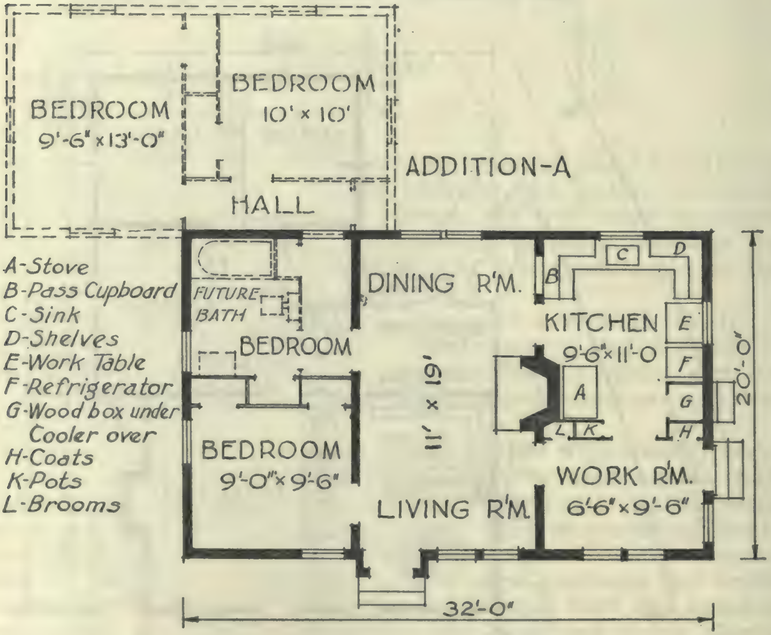
FLOOR PLAN OF THE COMPLETED HOUSE

PLAN 6522 [14]

Floor areas: Superstructure, original house 640 square feet; with addition *A* 950 square feet; with addition *B* 930 square feet. Porch, addition *B*, 120 square feet.

On account of its compact arrangement, this low-cost house furnishes a very satisfactory amount of usable space for the small family and may be enlarged to three-bedroom size, as indicated on the plans. The kitchen is well arranged, with moderate storage space, and a wood box filled from outside, with a ventilated cupboard or cooler above it. The workroom, unusually large for a small house, is a good place for laundry or canning and for men to clean up before coming in to meals. Dining space is provided at the rear of the living room. This house should be compared with no. 6527 (p. 36).

Board and batten construction is very suitable for a low-cost house, but any other type of construction may be used for plan 6522 if preferred. If the house is built in a cold climate, probably it will be desirable to omit the fireplace and heat the living and bedrooms with a circulator heater.



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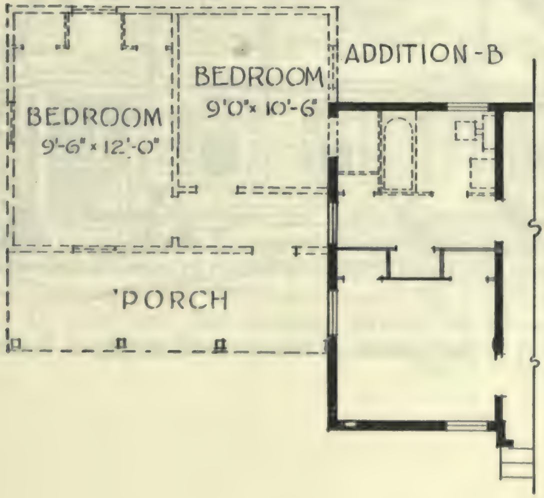
[14] Prepared by the Bureaus of Agricultural Engineering and Home Economics, U.S. Department of Agriculture.


ADDITION - B
BEDROOM
9'-0" × 10'-6"
BEDROOM
9'-6" × 12'-0"
PORCH

PLAN 6523,[15] FOR THE SOUTH

Floor areas: Superstructure, first unit 990 square feet; with addition *A* 1,420 square feet; with addition *B* 1,375 square feet. Cellar, 350 square feet. Porches, 100 square feet.

Communication between rooms is an important consideration in modern house planning. This has been provided in house 6523 by a small hall, which permits access not only from one room to another but also to the outside, the basement stairs, the wash room, the bathroom, and the linen closet, thus eliminating the necessity of using any room as a passageway.

Alternate extensions are shown, the choice probably depending upon the surrounding ground contour. Addition *B* should receive first consideration, because it brings the two new bedrooms into closer relation with the bathroom and does not destroy the wash room adjoining the rear entrance. It does, however, reduce the size of one of the first bedrooms.

If addition *A* is contemplated, the window at *X* should be located at *Y* when the first unit is built. The steps in the hall of addition *A* may be omitted if the ground slopes down at the rear so that the floor of the addition can be built at a lower level than the floor of the original house.

If addition *B* is to be used, the window at Z should be located so as to come in the hall of the addition.

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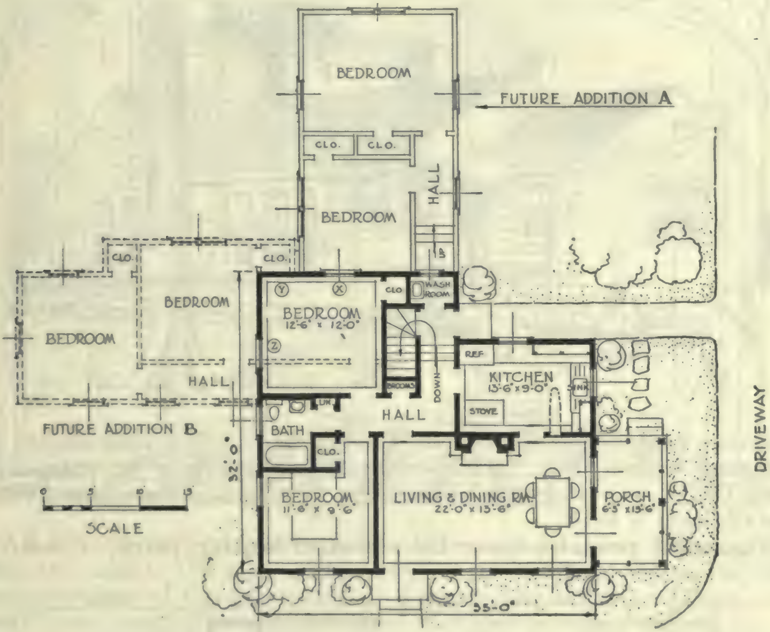
[15] Prepared by C. W. Heery and B. G. Danner for the department of agricultural engineering, University of Georgia.

The original house is compact and of pleasing design. The high sloping roof with louvers in the gables affords air circulation to aid in keeping the house cool in warm climates. The attic space may be used for storage; it is reached by stairs over those to the cellar or through a trap door in the ceiling. There is also space for a good-sized room in the attic over the bathroom, but if such a room is wanted the ceiling joists should be made 2 by 8 inches, instead of 2 by 6 inches as specified in the working drawings, the walls and ceiling of the room should be insulated for comfort both in summer and in winter, and a double window in the end wall and a dormer window at the rear should be provided, to give cross ventilation.

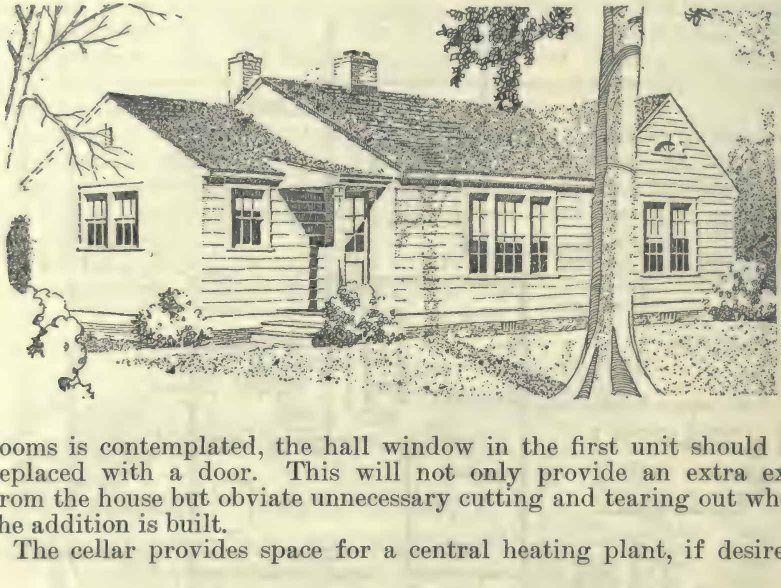


The working drawings provide for a piped warm-air furnace in the cellar, which occupies one corner of the space under the house. If no cellar is wanted, the stairs could be omitted and the original house, without the additions, could be heated nicely by a circulator heater in the hall. In this case the fireplace should be moved about 18 inches to the left to give a flue connection in the hall.

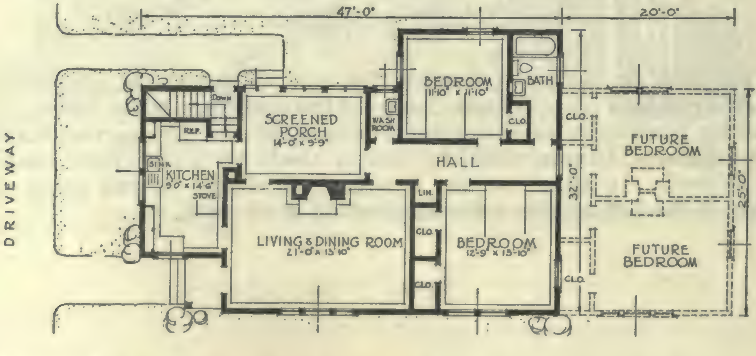
PLAN 6524[16]

Floor areas: Superstructure, first unit 1,245 square feet; with addition 1,735 square feet. Porches, 25 square feet. Cellar, 400 square feet.

The charm of house 6524 lies in its informality and simplicity. It is built for comfort and service. The broad expanse of roof, relieved by a gable, gives it a substantial yet homelike appearance. This is an easy house to move around in, and the kitchen is very nicely arranged. The screened porch, in addition to providing a cool and inviting summer dining and work space, affords ready access to all the rooms of the house. If the future addition of bedrooms is contemplated, the hall window in the first unit should be replaced with a door. This will not only provide an extra exit from the house but obviate unnecessary cutting and tearing out when the addition is built.



The cellar provides space for a central heating plant, if desired.



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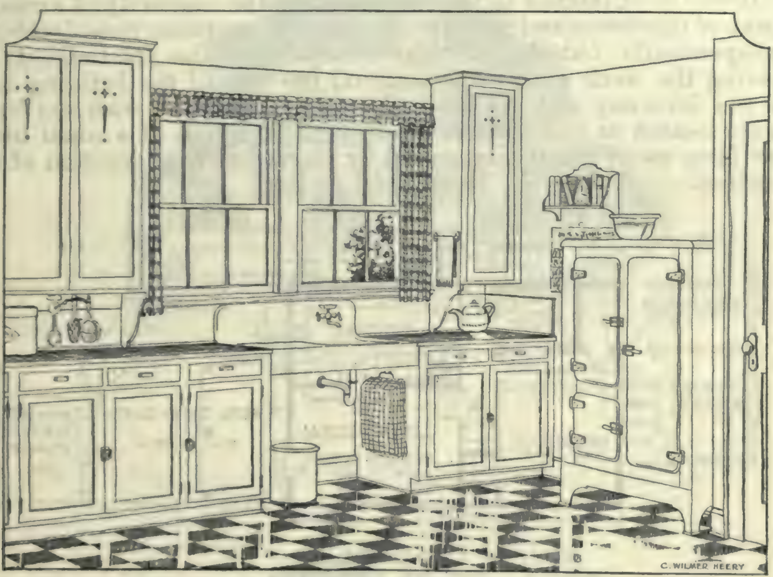
[16] Prepared by C. W. Heery, Fred J. Orr, and B. G. Danner for the department of agricultural engineering, University of Georgia.

The interior view shows the efficient kitchen arrangement and ample cabinet space planned for this house. Note that the sink drainboard is at the left for most convenient work by the average right-handed person, and that there is ample space for stacking soiled dishes at the right of the sink. The broad work shelf is 35 inches above the floor—a good average height—and there is toe space at the front for comfort while standing. The space under the sink is left clear so that the housewife may sit comfortably on a stool for the longer jobs.



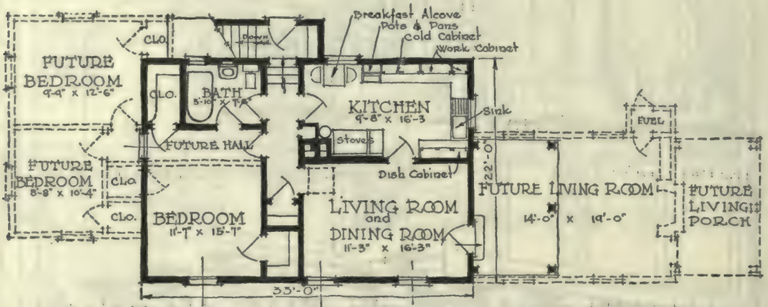
All the cabinets are shown with doors, which aid in keeping out dust and add to the neat appearance of the kitchen. However, the main purpose of the cabinets is to provide ample work surface and shelf space, and if money is scarce the first economy should be to omit the upper doors. They may be added later, or a roller window shade may be mounted above the shelves and drawn down to cover them when not in use.

PLAN 6525[17]

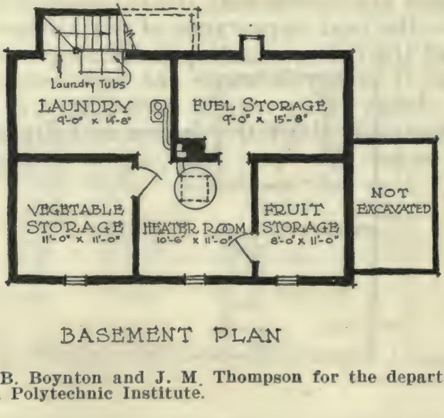
Floor areas: Superstructure, first unit 795 square feet; with bedroom addition 1,080 square feet; with both additions 1,375 square feet. Porches, 105 square feet. Cellar, 795 square feet.

This simple farmhouse develops into a home of dignity and charm. The original unit furnishes all modern conveniences and an ample basement. Future bedrooms may be added as required, while the extended living room might be built as the final touch of growing prosperity.

It will be of interest to the reader to note the similarity of arrangement of this house and no. 6519 (p. 20). These plans were developed independently, but the coincidence emphasizes the practicability of having the work and living areas on the side of the building next to the driveway and the bedrooms toward the rear, with the bathroom located as centrally as possible. The design of a small house for farm use is greatly influenced by the rather fixed location of the kitchen.



MAIN FLOOR PLAN
SHOWING FUTURE ADDITIONS


Laundry Tubs
LAUNDRY 9'-0" x 14'-8"
FUEL STORAGE 9'-0" x 15'-8"
VEGETABLE STORAGE 11'-0" x 11'-0"
HEATER ROOM 10'-6" x 11'-0"
FRUIT STORAGE 8'-0" x 11'-0"
NOT EXCAVATED

BASEMENT PLAN

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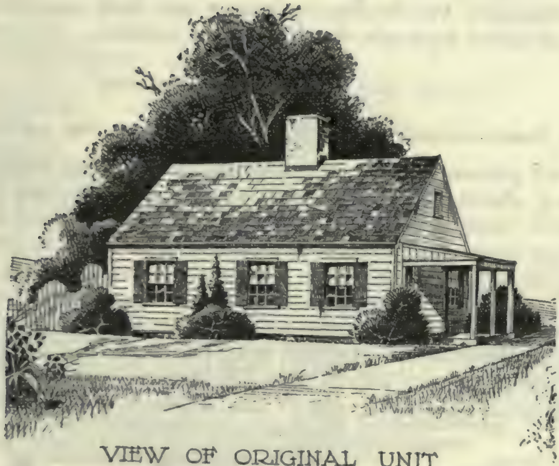
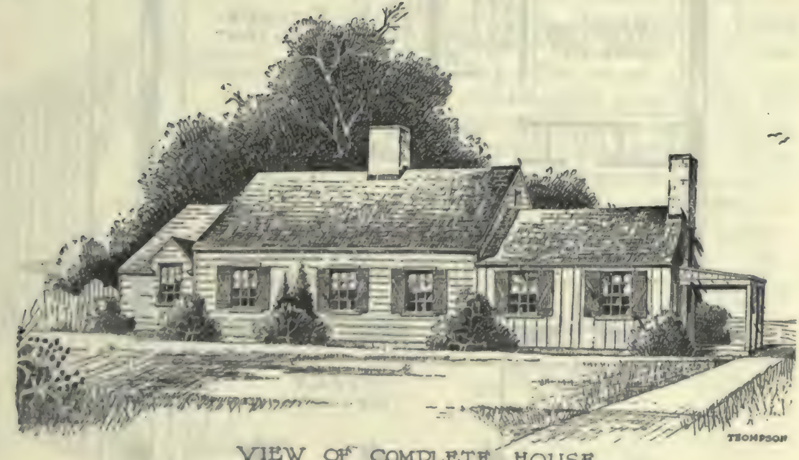
[17] Prepared by H. B. Boynton and J. M. Thompson for the department of agricultural engineering, Virginia Polytechnic Institute.



VIEW OF ORIGINAL UNIT



VIEW OF COMPLETE HOUSE

MODERATE-SIZED ONE-STORY HOUSES

Houses of this group can best be built complete at one time, though in several cases it is noted that rooms may be omitted from the original building or extra rooms added. The larger houses of this group provide about the same features as the completed growing houses. The more compact two-bedroom houses are well adapted to farms where two or more separate dwellings are needed.

PLAN 6526,[18] FOR TIMBERED SECTIONS

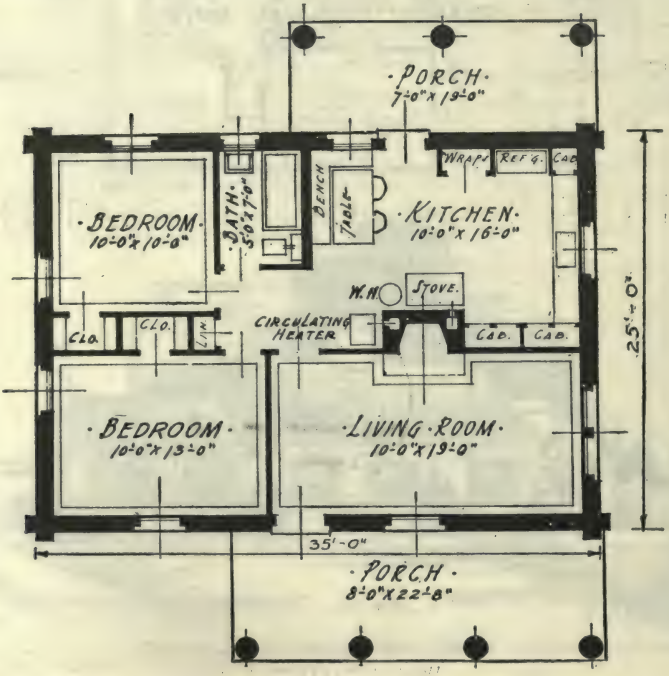
Floor areas; Superstructure, 845 square feet. Porches, 300 square feet.

In spite of present-day improvements in building materials, there is something about the rugged appearance of a log cabin that harmonizes with rural settings. Log construction blends into wooded surroundings more intimately than boards, bricks, or stucco.

House 6526 will accommodate 4 persons comfortably, or even 5 or 6 persons if a couch is placed in a corner of the living room.

The location of the bathroom not only serves the bedrooms but is convenient to the kitchen and the rear porch.

The central chimney serves the kitchen range, circulator heater, and fireplace. The ample size of the kitchen, and its built-in cup-



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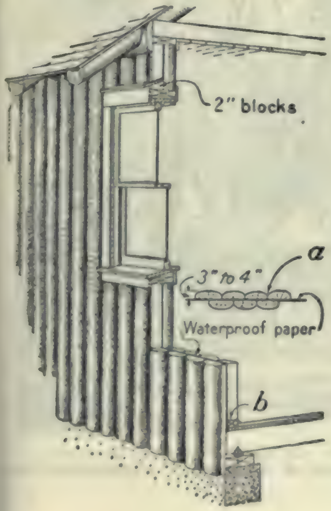
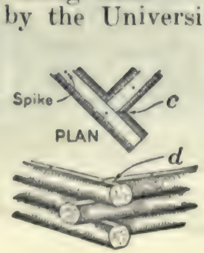
[18] Prepared by N. G. Napier for the department of agricultural engineering, University of Arkansas.

boards, dish cabinets, and other conveniences add greatly to the desirability of the design. If a pass cupboard between kitchen and living room is desired, it may be arranged in the cabinet next to the outer wall.

Many of the houses shown in this bulletin could be built of logs, with little change in detail. Farmers' Bulletin 1660, The Use of Logs and Poles in Farm Construction, describes several methods of using logs. The illustrations below show the economical use of slabs and flattened logs. The edges of the slabs should be cut to make close joints (*a*) and sill thickness should equal that of floor and quarter round (*b*). With horizontal flattened logs, at corners the projecting log should be notched to obtain a tight joint (*c*), and the projection sloped to shed water (*d*). This method of using slabs for walls was suggested by the University of Wisconsin.



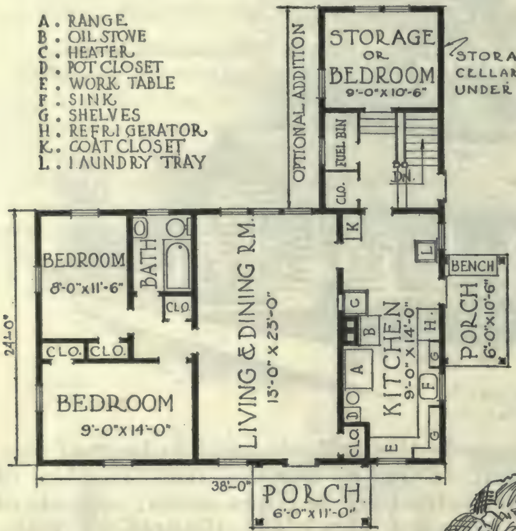


PLAN 6527 [19]

Floor areas: Superstructure, main house, 915 square feet; with storage addition 1,120 square feet. Cellar, 115 square feet. Porches, 130 square feet.

This house is similar in many respects to the first unit of 6522 (p. 26), but is enlarged to provide for the bathroom. A shallow root cellar with room above is added at the rear of the house to provide extra storage if needed in localities where a cellar is not practicable. As in the case of plan 6522, two more bedrooms may be added to the left side of the house by taking space from the rear bedroom for a hallway.

The house is planned to be heated by a jacketed heater in the workroom with a cold-air return duct under the floor and cold-air registers in the living room and bedrooms. This arrangement will keep all handling of coal and ashes out of the living parts of the house.



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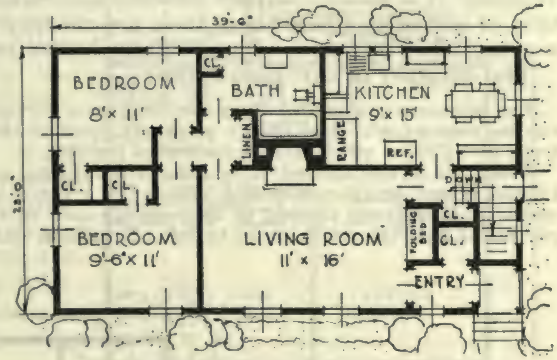
[19] Prepared by O. R. S. Trabor for the department of agricultural engineering, University of Missouri.

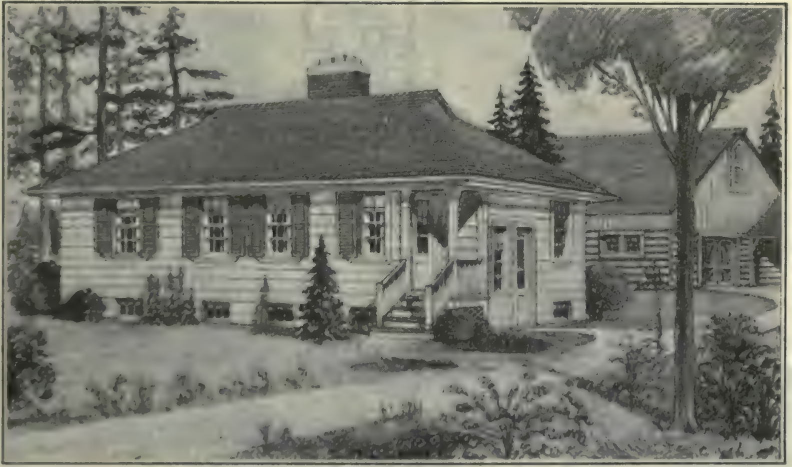
PLAN 6528,[30] FOR THE NORTH

Floor areas: Superstructure, 800 square feet. Cellar, 800 square feet.

House 6528 is intended for use in cold, snowy regions, where farmers need cellars for storing fuel and vegetables. The hip roof helps to brace the house against the wind and is economical of material. A well-insulated ceiling is recommended to help keep the house comfortable. The substantial chimney in the center of the house, with separate flues for furnace, kitchen range, and fireplace, insures good draft and no wasted heat. The vestibule at the front and the hall arrangement at the side door also aid in keeping the house warm. Both doors are convenient to the driveway and the path to the barn.

The wash room and laundry of this house are in the cellar. This is a satisfactory and economical arrangement where there is good drainage for both the cellar and the plumbing fixtures, and is particularly advantageous on rolling ground. But one should beware of putting a deep cellar in a poorly drained location. (See Farmers' Bulletin 1572, Making Cellars Dry.)





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[30] Prepared by S. A. Witzel for the department of agricultural engineering, University of Wisconsin.

PLAN 6529[21]

Floor areas: Superstructure, 740 square feet. Porches, 250 square feet.

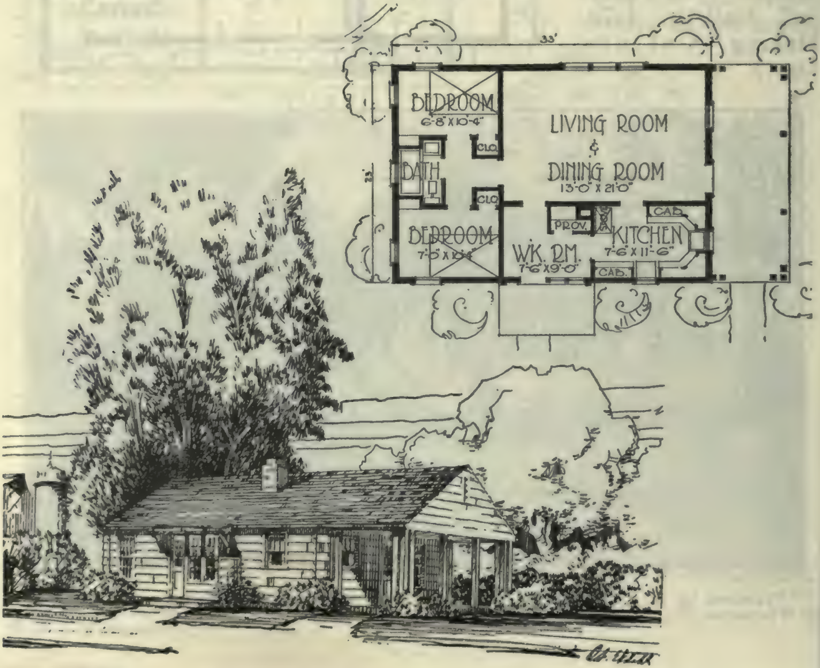
This house was designed to meet the needs of a family of 4 to 6 people. The porch faces the highway, and paths from the front and side porches lead to the farm drive.

The kitchen is complete and compact. The extra space found in many farm kitchens has been omitted and a workroom added to provide for laundry and other rough work. This also provides a place for men to leave their outer wraps and wash before entering the living room. Storage space can be obtained in the attic by the use of a disappearing stair in the workroom ceiling.

No wood or coal range is provided for in this plan, because the use of an oil, gas, or electric stove saves space in the kitchen and correspondingly reduces the cost of the house. This saving and the convenience of a small, compact cooking unit deserve careful consideration in localities where these fuels are cheaply available. Heating is accomplished by means of a circulator heater in the living room.

The designer of this plan states:

> The bedrooms are small. They are little used during waking hours, thus they can be reduced with less injury to family comfort than any other room. The large living room more than compensates for this.
>
> When funds are limited it is always debatable, in a great portion of the United States, whether spending money for a porch is wise, because the same money could be used instead to increase the area of the house proper. In this particular case the porch could be left off without harm.



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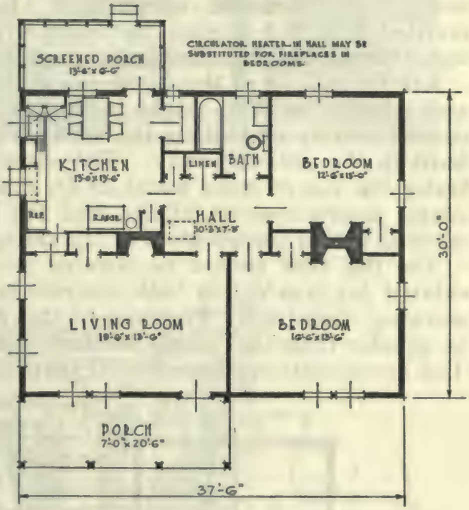
[21] Prepared by H. E. Wichers and O. S. Ekdahl for the department of architecture, Kansas State Agricultural College.

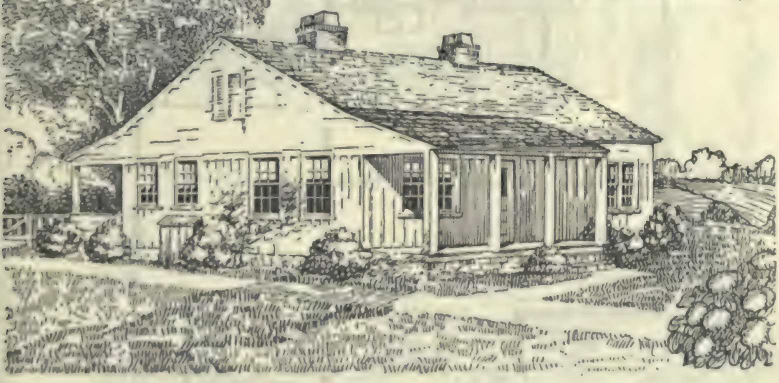
PLAN 6530 [22]

Floor areas: Superstructure, 1,155 square feet. Porches, 245 square feet.

The well-known economy of square house construction is illustrated by this plan. A choice of heating methods without a cellar is indicated. If a circulator heater is used in the hall, as shown, the chimney between the bedrooms will not be needed, and if extra bedrooms are wanted they may be added as in plan 6517 (p. 18). A fireplace in the back bedroom would, of course, interfere with taking a hall off this room.

Kitchen doors are located to permit easy communication between the screened porch and the hall without interference with the work area while the screened porch is useful as both work and dining area. This latter feature, together with the ample size of the bedrooms, living room, and kitchen, makes the dwelling especially suitable for the small family in the South. The addition of a cellar under one-half of the house and of a central heating plant would adapt this plan to other sections of the country, though the rooms are rather larger than is common in the North.





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[22] Prepared by W. C. Breithaupt and H. W. Dearing for the department of agricultural engineering, Alabama Polytechnic Institute.

PLAN 6531[23]

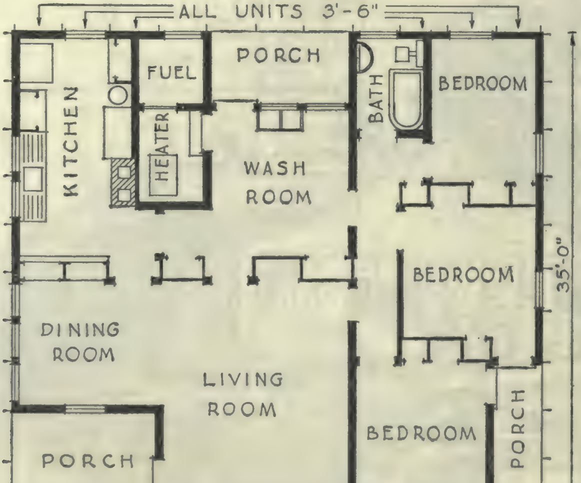
Floor areas: Superstructure, 1,185 square feet. Porches, 155 square feet.

House 6531 should be compared with no. 6533. The two plans were developed independently, but are very similar and illustrate a logical grouping of rooms for a farmhouse. In some respects the arrangement of 6531 works out more satisfactorily because it is not restricted by the structural details of framing a pitched roof.

This house is a model of compactness and efficiency. Note the simple but effective way in which the kitchen and heater room are located back to back. The floor of the heater room is a concrete slab, two steps below the main floor level. A pass cupboard between the kitchen and dining room is handy for serving meals. It also provides storage space beneath its counter. The entire bedroom side may be omitted from the original house, in which case the workroom would serve for dining and the dining room for a bedroom.

All dimensions of this house are multiples of 3½ feet. Wall, door, and window sections might be prefabricated so that erection would consist merely of bolting the sections together, or the house can be built in the ordinary way. The sketch at the top of page 41 illustrates the use of sheet metal as an exterior covering, the one in the center shows concrete blocks, and the bottom view shows the walls covered with a combination of lap siding and shingles or wide boards.

The flat roof should be covered with good roofing and well insulated for comfort in both summer and winter as described in the working drawings. The cost of the insulated flat roof should not be greater than that of an ordinary pitched roof without insulation. The accumulation of snow will help to keep the building warm.



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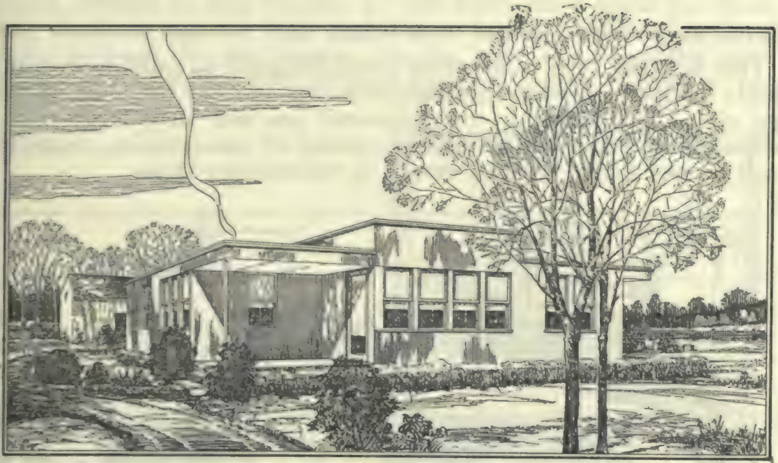
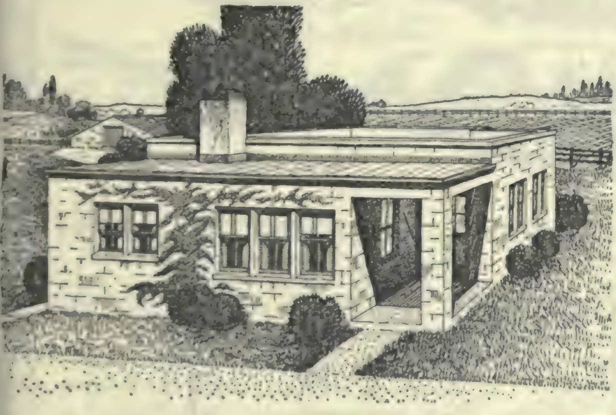
[23] Prepared by Albert Frey for the Bureaus of Agricultural Engineering and Hom Economics, U.S. Department of Agriculture.

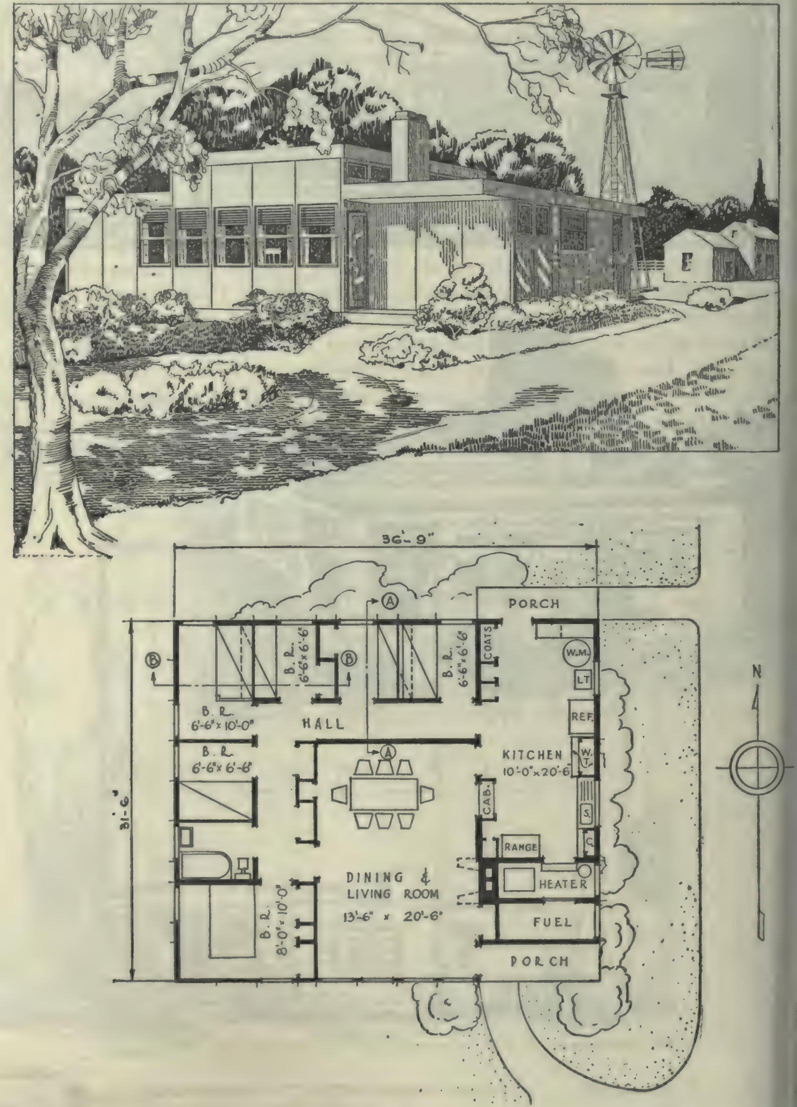




PLAN 6532[24]

Floor areas: Superstructure, 1,125 square feet. Porches, 35 square feet.

This is a new type of low-cost house designed to provide five small single bedrooms or sleeping compartments and one bedroom of average size. The sleeping compartments are not very large, but to secure privacy and yet maintain economy of construction, something must be sacrificed. In this case it is unnecessary space.



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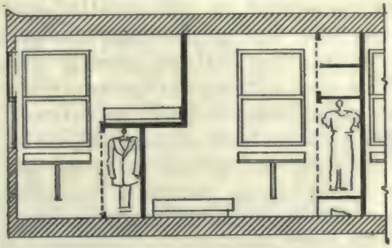
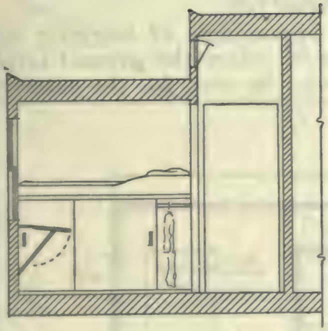
[24] Prepared by Albert Frey and R. G. Allen for the Bureaus of Agricultural Engineering and Home Economics, U.S. Department of Agriculture.

The sketch showing the arrangement of bunks illustrates an interesting feature of this house. In the right-hand room the bunk is near the floor, and wardrobe and dresser space is obtained in the partition between the two rooms. In the left-hand room the bunk is 4 feet above the floor and projects over the one on the other side of the partition. Wardrobe space is arranged under the bunk. This room is especially suitable for a boy. A folding study table is provided under the window in each room. On warm nights air circulation would be obtained by opening the bedroom doors to the hall, which is ventilated by the windows above the lower roof. By omitting all but one of the partitions forming the five small bedrooms two good-sized rooms can be obtained.



CROSS SECTION OF BEDROOMS AND WARDROBE AT B-B



SIDE VIEW OF BUNK AT A-A

The exterior appearance may seem, at first glance, unusually severe, but by omitting a pitched roof and the ornamental features of cornice moldings and trim decorations, the cost of construction is materially lowered. Here everything has been reduced to the simplest form possible.

With the heater room adjoining the kitchen, there is little need for a basement, thus an important item of expense is eliminated. The kitchen and workroom form a compact and very convenient unit along the driveway side of the house, while the large living room commands a good view of the highway. The living room and halls are lighted and ventilated by the small windows above the lower roofs. Closet space is provided in every room.

As in plan 6531 (p. 40), all dimensions are multiples of 3½ feet so that the house can be either prefabricated or built in the ordinary way.

PLAN 6533[25]

Floor areas: Superstructure, 1,130 square feet. Porch, 80 square feet. Cellar, 280 square feet.

House 6533 is one of the few designs in which a separate dining space was allotted. Many people do not consider a separate dining room essential in the small farmhouse, and additional space adds to the cost, but in this case the arrangement adds to the spaciousness of the interior without greatly increasing the cost.

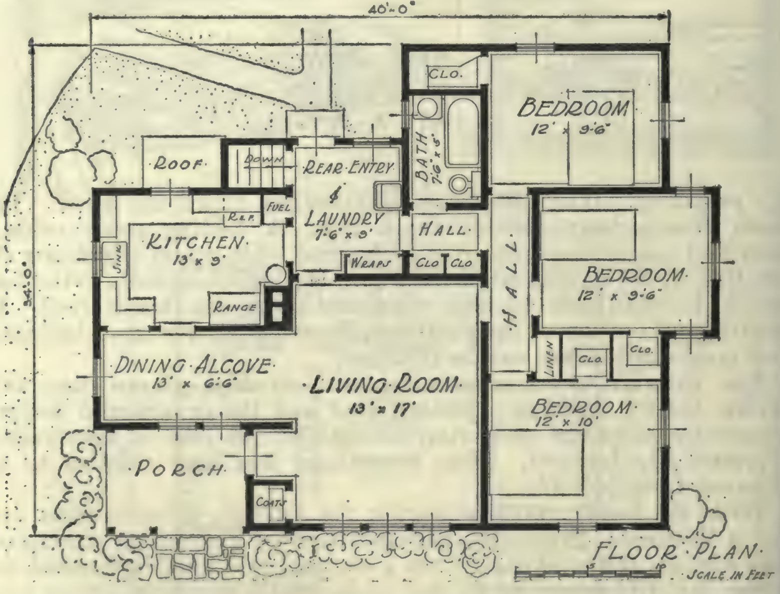
The rear entry is large enough to serve as laundry and washroom, and constitutes a back way from the kitchen to the bedrooms and bathroom without passing through the living room.

The kitchen, with cross ventilation and ample cupboard and counter space, is a pleasant workshop for the housewife, and is so arranged that easy service to the dining alcove is possible.

The bedrooms and adjoining bath are grouped together, allowing that portion of the house to be closed off from the living portion.

In the cellar is the heating plant, with fuel bin.

The house is kept low to give it an appearance of hugging the ground, but in no case should the joists be below the ground level. Shingles, beveled siding, or clapboards may be used for the exterior surface.



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[25] Prepared by Max Uhlig for the department of agricultural engineering, Massachusetts Agricultural College.

HOUSES OF MORE THAN ONE STORY

In many respects houses of more than one story are better suited for farm use in the Northern States than single-story buildings. They are more economical in foundation and roof construction, and are easier to heat. They should be arranged with one bedroom and a bath, or at least a toilet, on the ground floor. A cellar for fuel and vegetable storage and a central heating plant are usually needed with this type of house. The laundry may also be located in the cellar if suitable drainage and a grade door to the outside can be obtained, but in a poorly drained location it is best to keep the laundry aboveground. In building a cellar advantage should be taken of the slope of the ground to obtain good lighting and an easy entrance on the low side of the slope.

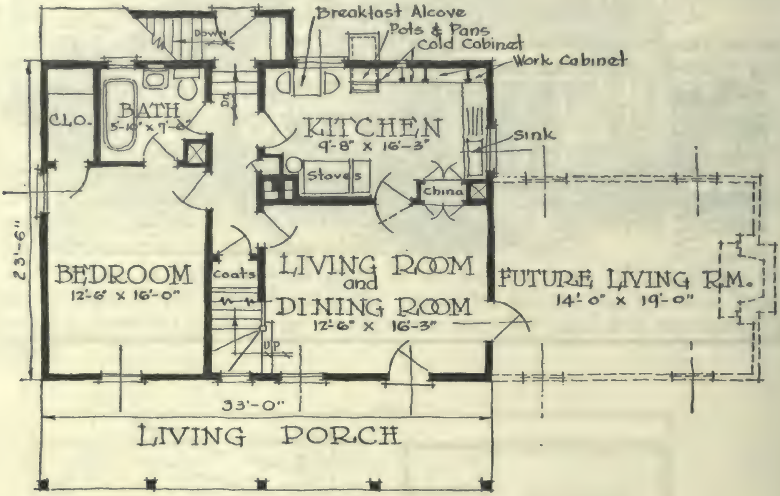
To avoid uncomfortably warm second-floor bedrooms in summer cross ventilation should be provided in each room. Insulation of the ceiling is valuable both in summer and in winter.

It is very convenient to have a bathroom on the second floor as well as one on the first floor, especially if rooms are to be rented to tourists when the family does not need the whole house.

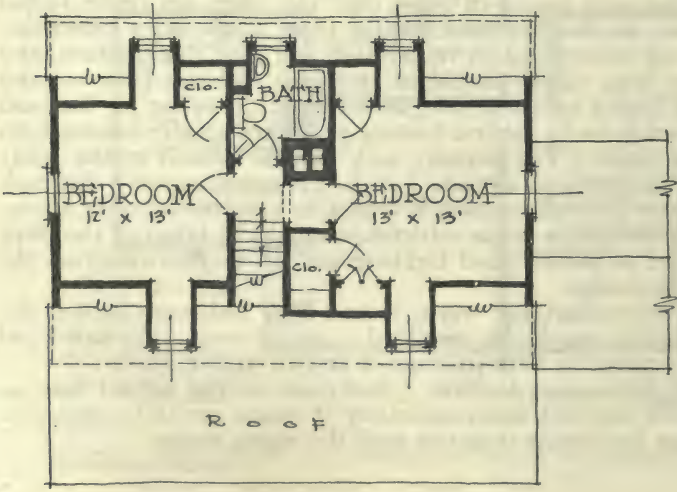
PLAN 6534[26]

Floor areas: Superstructure, original house, 1,420 square feet; with living-room addition, 1,720 square feet. Cellar, 775 square feet. Porches, 285 square feet.

The first-floor and cellar plans of house 6534 are almost the same as the original unit of no. 6525 (p. 32), but there are comfortable



MAIN FLOOR PLAN
SHOWING FUTURE ADDITION



SECOND FLOOR PLAN

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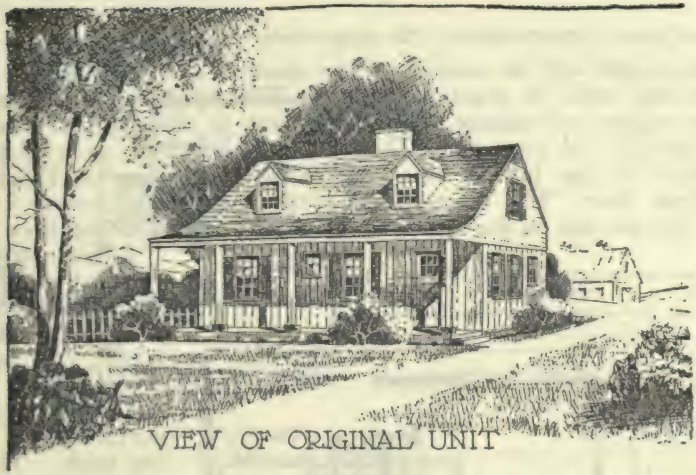
[26] Prepared by H. B. Boynton and J. M. Thompson for the department of agricultural engineering, Virginia Polytechnic Institute.

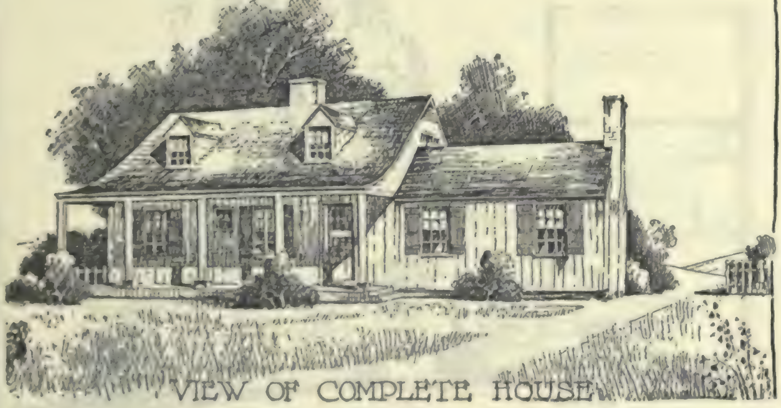


VIEW OF ORIGINAL UNIT

bedrooms, a bath, and closet space on the second floor. If funds are available to build the living-room wing indicated, the entire dwelling will breathe the traditional southern spirit of hospitable spaciousness.

The hall and stair arrangements of this house are very good. Persons coming in at the back door can leave wraps in the vestibule at the head of the cellar stairs and go directly to any downstairs room or to the cellar, yet there is little lost space.

If the house should at some time be occupied by a small family, the entire upstairs could be shut off. Persons wishing rooms for tourists will find either the upstairs bedrooms or the downstairs bedroom and bath very suitable for this purpose.

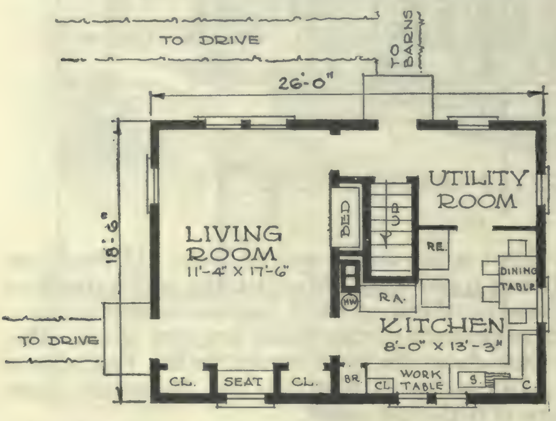


VIEW OF COMPLETE HOUSE

PLAN 6535 [27]

Floor areas: Superstructure, 820 square feet. Porch, 30 square feet.

This might well be considered the smallest story-and-a-half farmhouse that could be practicably built. The designer has utilized the space to good advantage, omitting a bath in the original structure for the sake of economy. The working drawings show a future addition to the house which provides a bedroom and bath on the first floor. The alternate floor plan shows a dormer in the rear like the one on the front, to make room for a second-floor bath.



· FIRST · FLOOR · PLAN ·

A distinctive feature of this compact design is the L-shaped kitchen with its well-grouped and well-lighted working surfaces and dining table. The arrangement of an L-shaped room is often a problem when enlarging or remodeling. The living room is arranged for both day and night use, with a folding bed in a closet.

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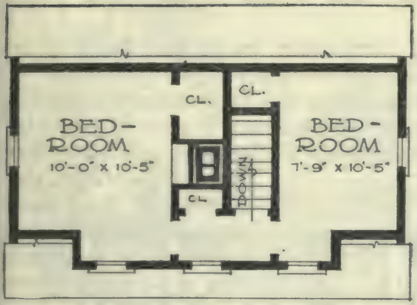
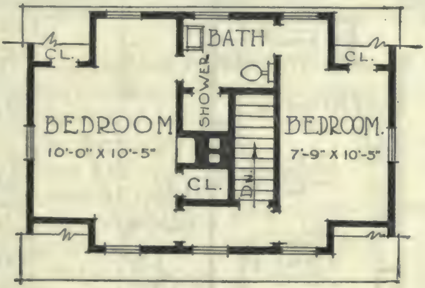
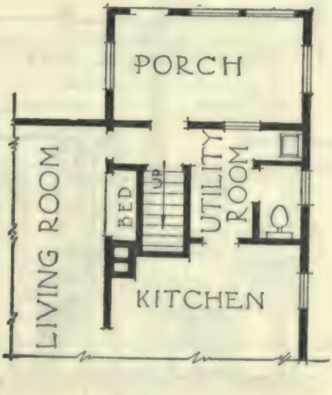
[27] Prepared by C. T. Bridgman for the department of agricultural engineering, Iowa State College.



SECOND · FLOOR · PLAN ·



ALTERNATE
·SECOND · FLOOR · PLAN ·

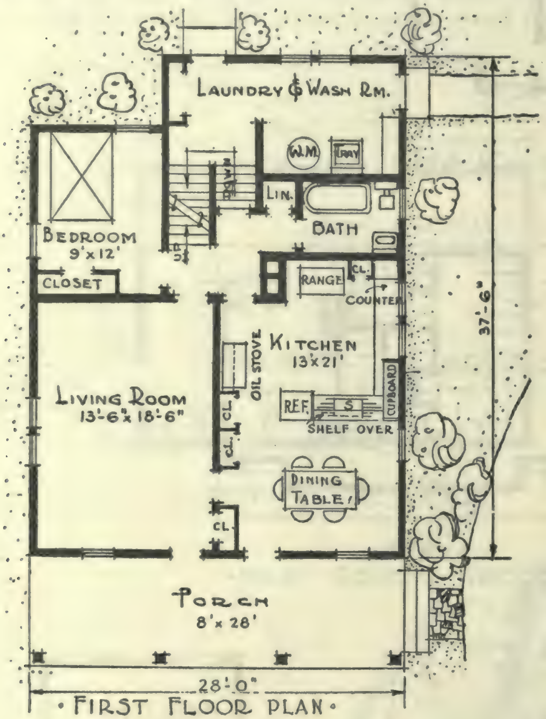


ALTERNATE
·FIRST · FLOOR · PLAN ·

PLAN 6536,[28] FOR THE NORTH

Floor areas: Superstructure, 1560 square feet. Cellar, 400 square feet. Porch, 210 square feet.

This design illustrates a type of farmhouse frequently built in recent years because of its simple lines and economy of construction. It illustrates the pleasing possibility of fitting the farmhouse to sloping ground, with ample light in the basement and easy flights of steps between the house proper, the large workroom at the rear, and the cellar.



The partition between the main rooms downstairs is carried up to divide the second floor, giving these bedrooms ample size and good cross ventilation and making a strong construction that will not sag in years to come. A second bathroom may be provided in the storage space by the chimney, thus adding to the comfort of the home and making the upstairs rooms suitable for rental to tourists if desired. The roof should be insulated to give comfort both in summer and in winter.

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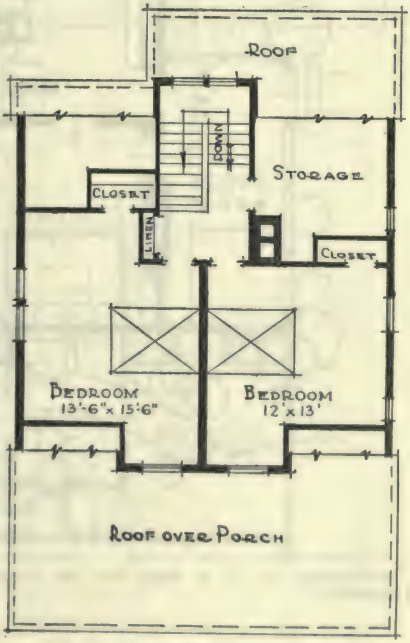
[28] Prepared by C. J. Poiesz and Eldred Mowery for the Bureaus of Agricultural Engineering and Home Economics, U.S. Department of Agriculture.

The downstairs hall, lighted by the windows on the stairs, is compact and provides easy communication between all rooms. The living room is well lighted and has good wall spaces for furniture. The combined kitchen and dining room, with the sink at right angles to the outside wall, as shown in the interior view, gives the housewife three walls of continuous work surfaces and in addition light and the view from all the windows of the room. Children can play or older members visit in the dining end with slight interference to the housewife's work. This is especially helpful on chilly days in the fall and spring when the kitchen stove provides the only heat in the house.

The part basement furnishes space for a furnace and for storage of fruits and vegetables.



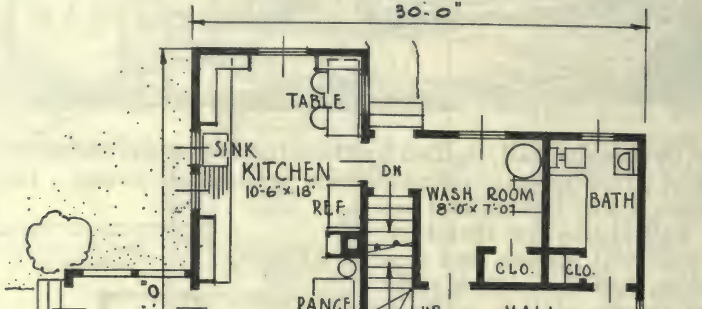
·SECOND FLOOR PLAN·

PLAN 6537 [29]

Floor areas: Superstructure (including enclosed porch) 1,520 square feet. Cellar, 840 square feet. Terrace and steps, 100 square feet.

House 6537 is similar in many respects to no. 6536, and has much the same advantages, though the rooms are somewhat smaller. A second downstairs bedroom can be added beside the bathroom, if needed, or the two bedrooms on the second floor can be left unfinished if funds are not on hand to complete the building in the beginning.

The sketch indicates the roof line sweeping down snug over the window of the first-floor bedroom, a feature which is carried out with similar success in plan 6538. Designs of this type help to keep a two-story home from appearing too tall and make it a more harmonious unit in the farmstead scheme.



FIRST FLOOR PLAN

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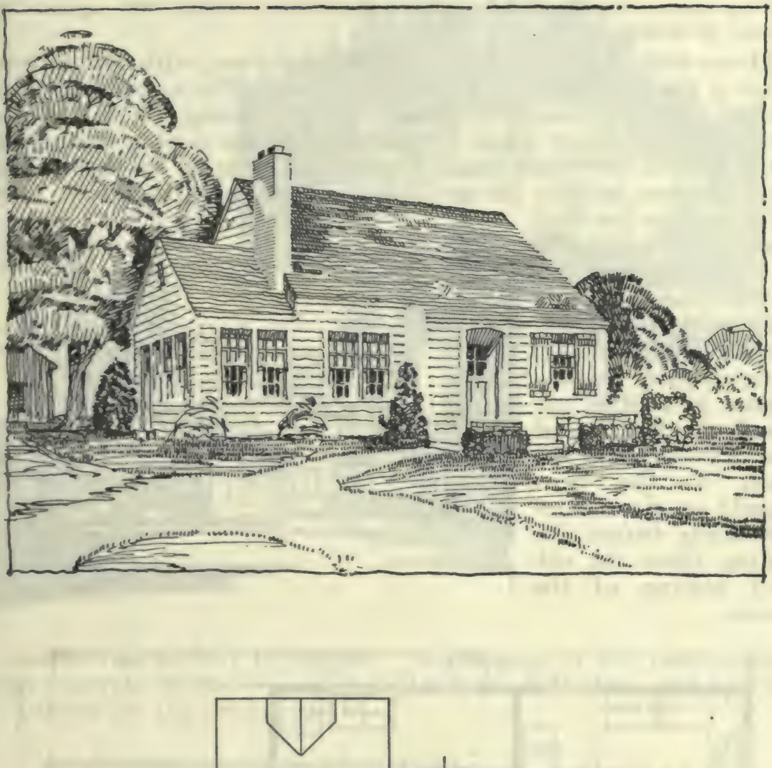
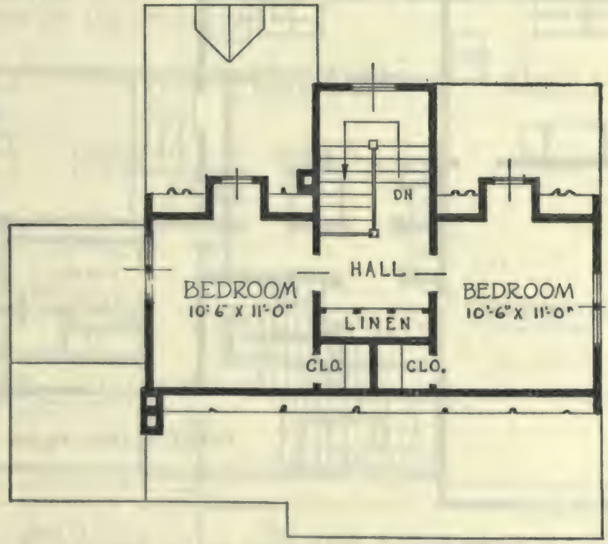
[29] Prepared by T. A. Zink for the department of agricultural engineering, Purdue University.





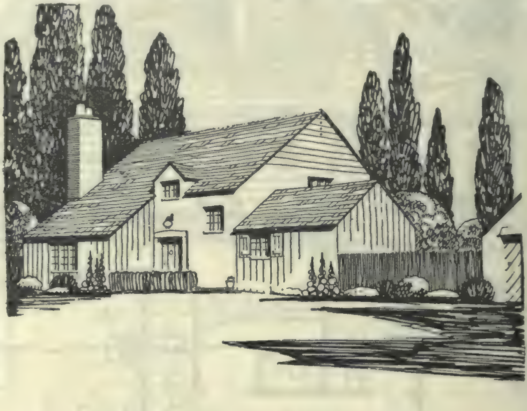
SECOND FLOOR PLAN

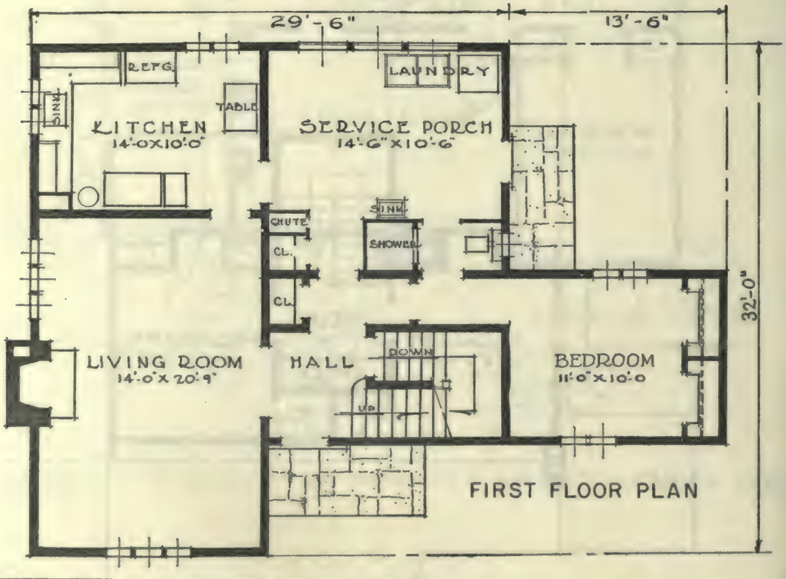
PLAN 6538 [30]

Floor areas: Superstructure, 1,740 square feet. Cellar, 385 square feet. Stoops, 80 square feet.

House 6538 may be roofed in a number of ways, with slight alterations in the arrangement of the second floor. The appearance is, of course, greatly altered; but in each case is pleasing. With the modernistic flat roof, any waste spaces caused by the sloping roofs in the other designs are eliminated. The storage room on the second floor then becomes suitable for a child's bedroom, a sewing room, or an office, and the flat-deck porch roof will serve as a sleeping porch.

The plan is simple and well proportioned. Since the arrangement of the entrance is a little unusual, the location of the driveway and the path to the barn should be given careful study before deciding upon the site and placing of the house.





FIRST FLOOR PLAN

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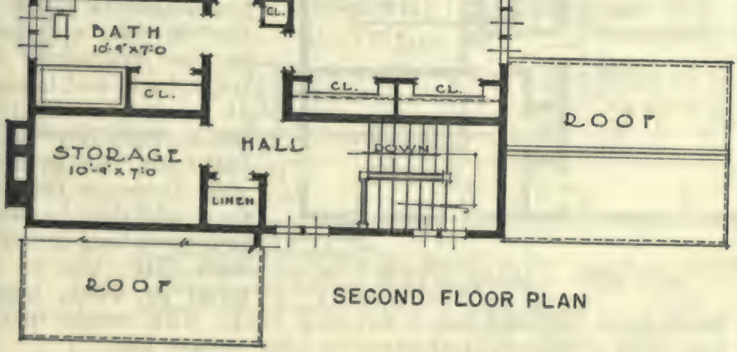
[30] Prepared by W. K. Bartges and Earl Barnett for the department of agricultural engineering, University of California.

Construction should be simple. In the case of the modernistic house, concrete or stucco is suggested for the first story and boards and battens for the second.



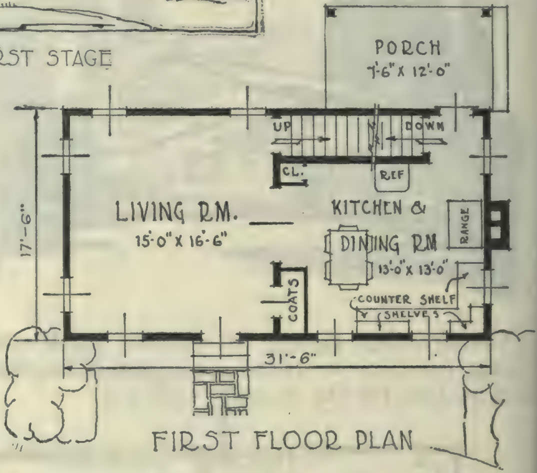
SECOND FLOOR PLAN

PLAN 6539,[31] FOR THE NORTH

VIEW OF FIRST STAGE

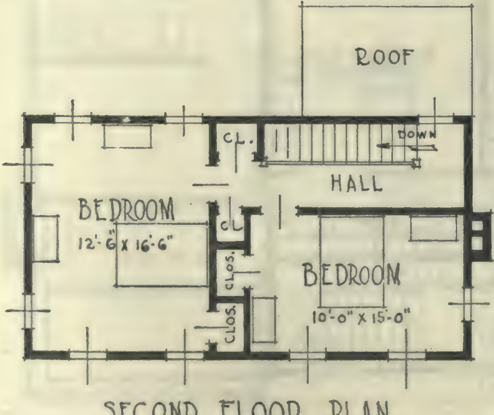
Floor areas: Superstructure, original house, 1,100 square feet; with kitchen addition, 1,270 square feet; with all additions shown, 1,620 square feet. Porches, original house, 90 square feet; completed house, 285 square feet. Cellar, 565 square feet.

Thousands of farmhouses in all parts of the North and Middle West have begun like house 6539, and the development illustrated for this one should offer helpful suggestions both to farmers who plan to build new and those who expect to remodel present houses. It is a very practical design, expressing honest dignity.



FIRST FLOOR PLAN

The plans on this page show the original unit, which would supply a comfortable yet economical dwelling, with a basement for fuel and storage. The first addition might be either the new kitchen and porch or the downstairs bedroom, bath, and laundry. If needed, a third upstairs bedroom and a bathroom can be added over those in the first-floor addition, as shown in the working drawings, with little loss of material or work, because the downstairs bedroom has a flat-deck roof. This would increase the floor area of the superstructure to 1,900 square feet.



SECOND FLOOR PLAN

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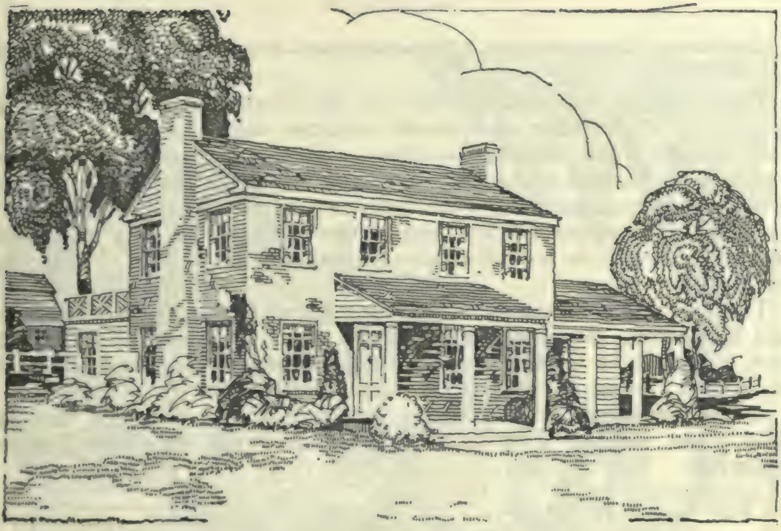
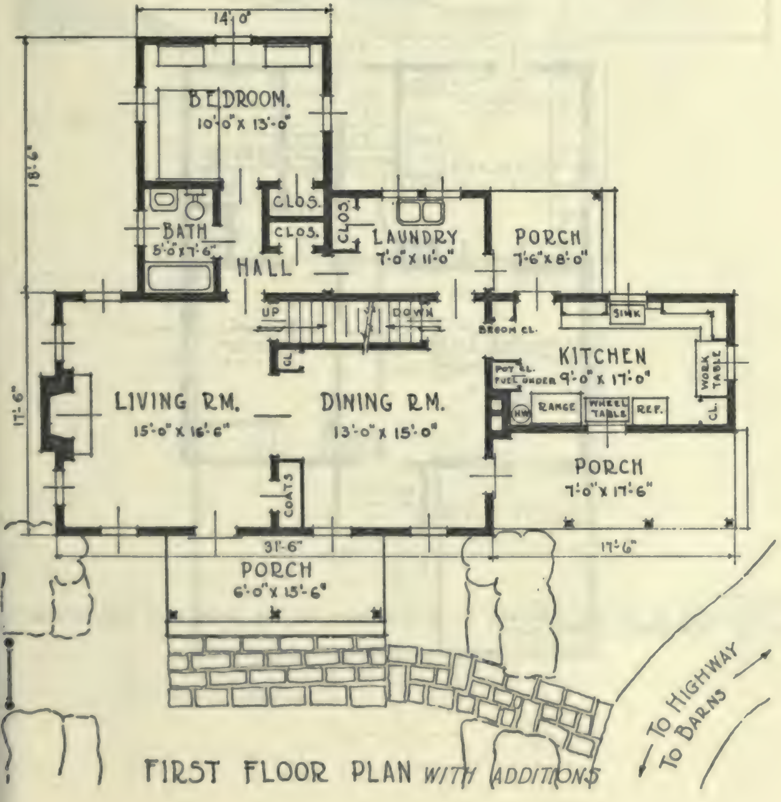
[31] Prepared by J. M. Deibert for the Bureaus of Agricultural Engineering and Home Economics, U.S. Department of Agriculture.



VIEW OF COMPLETED HOUSE



FIRST FLOOR PLAN *WITH ADDITIONS*

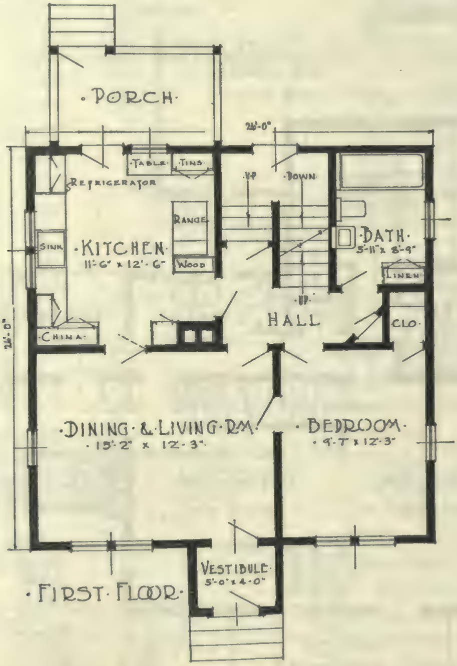
PLAN 6540 [32]

Floor areas: Superstructure, 1,380 square feet. Porch, 70 square feet. Cellar, 760 square feet.

This plan is intended for use in the North, where the compact floor plan with cellar and inside chimney and the front vestibule will simplify the heating problem. The first-floor level is above the ordinary height of packed snow in winter, but the grade entrance gives easy communication with both the cellar and the main part of the house. This permits convenient use of the cellar as a wash room and laundry, if in a well-drained location, as well as for storage purposes.

The house is roomy and well arranged, with a downstairs bedroom and bathroom. By a slight change to make the second floor like the first, a bathroom or toilet could be arranged in the large closet by the stairs. Storage space is provided in the attic.

All second-floor partitions are directly above those of the first floor, thus making a strong, rigid house with the least framing material.



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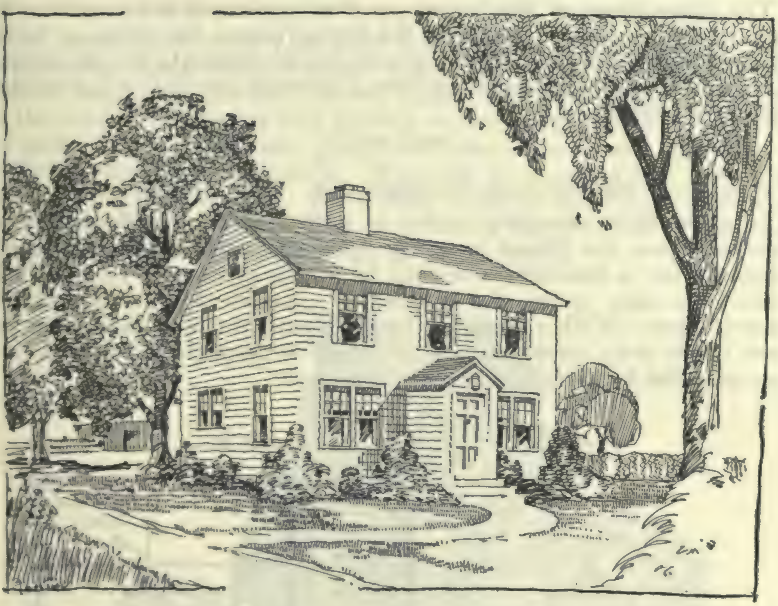
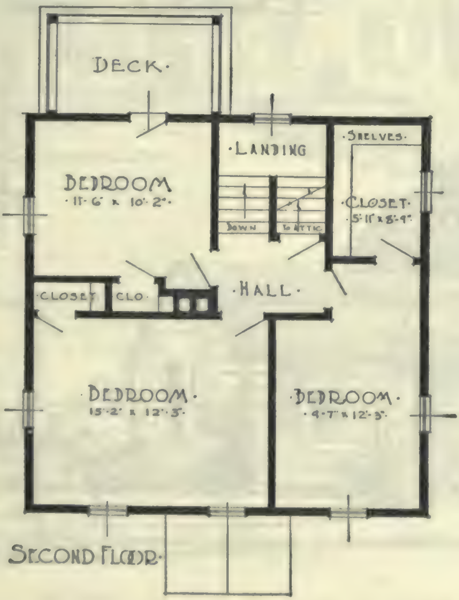
[32] Prepared by H. W. Orth and R. A. Gmeinder for the division of agricultural engineering, University of Minnesota.




DECK
LANDING
BEDROOM
11'-6" x 10'-2"
DOWN
TO ATTIC
SHELVES
CLOSET
5'-11" x 8'-9"
HALL
CLOSET
CLO
BEDROOM
15'-2" x 12'-3"
BEDROOM
9'-7" x 12'-3"
SECOND FLOOR

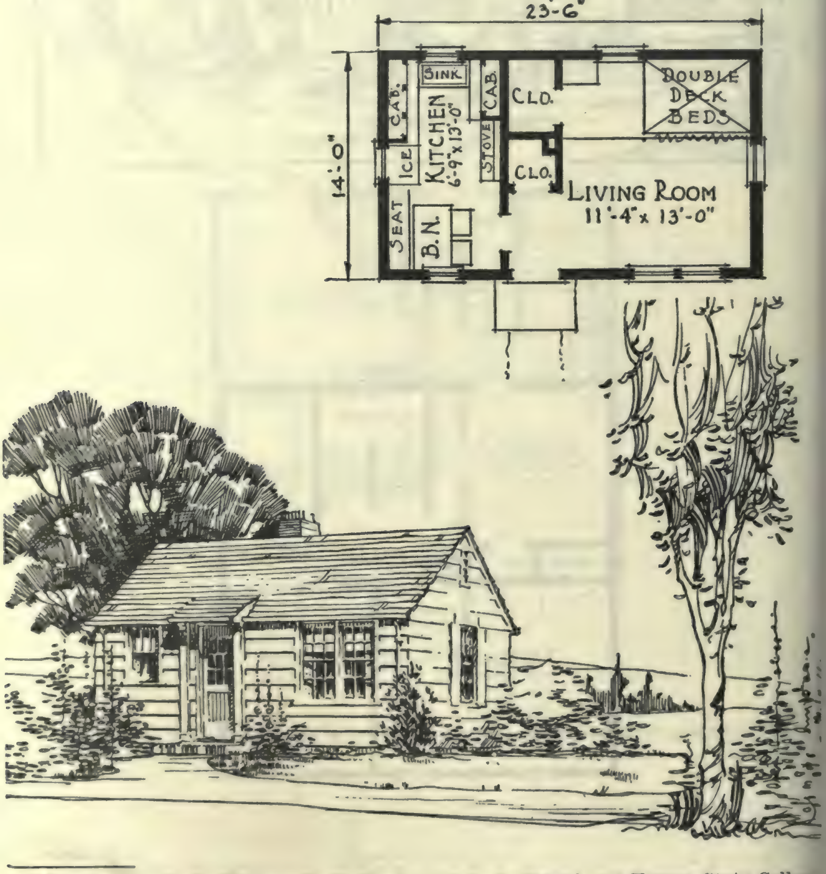
VERY SMALL HOUSES

The dimensions of the houses in the very-small-house group are kept to the minimum by using the living rooms for sleeping rooms at night. These houses cannot be considered adequate for the typical farm family, but will serve for young married couples or for tenants with small families.

PLAN 6501[33]

Floor areas: Superstructure, 325 square feet. Stoop, 15 square feet.

In plan 6501, sleeping space is provided in double-deck beds screened from the living room by draw curtains. If more space is wanted later, a bedroom wing can be added at the end of the living room. To save space, the kitchen is planned for an oil, gas, or electric stove. With a house of this size, part of the housework would have to be done outdoors, and a paved or graveled space under a tree near the house would be a convenience.



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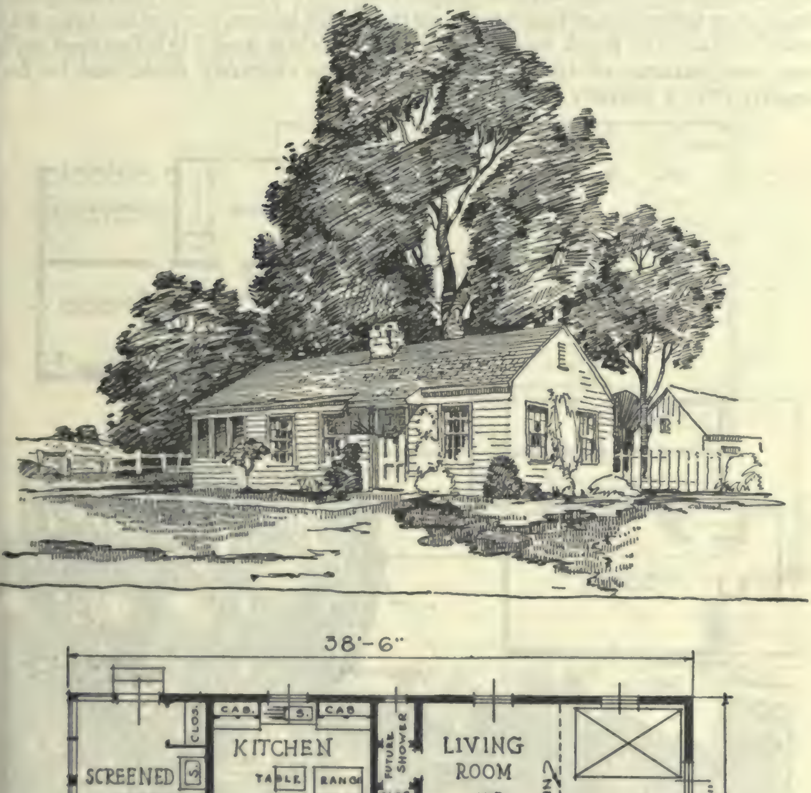
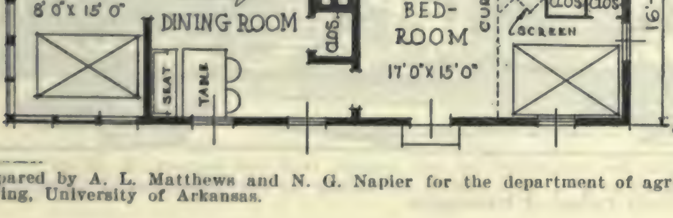
[33] Prepared by H. E. Wichers, N. F. Resch, and O. S. Ekdahl, for Kansas State College.

PLAN 6502[34]

Floor areas: Superstructure, 600 square feet. Stoop, 35 square feet.

The special feature of plan 6502 is the well-arranged kitchen, with good storage space and a compact work area at one side of the direct line of travel from the back door. Some privacy at night is afforded by the double wardrobes and folding screen between the two beds in the living room. The side porch will serve the double purpose of workroom and sleeping porch. It should be screened and have curtains to keep out the rain. By adding 4 feet to the living room and an additional partition, a third room could be provided. A shower bath may be installed in the large closet as shown.





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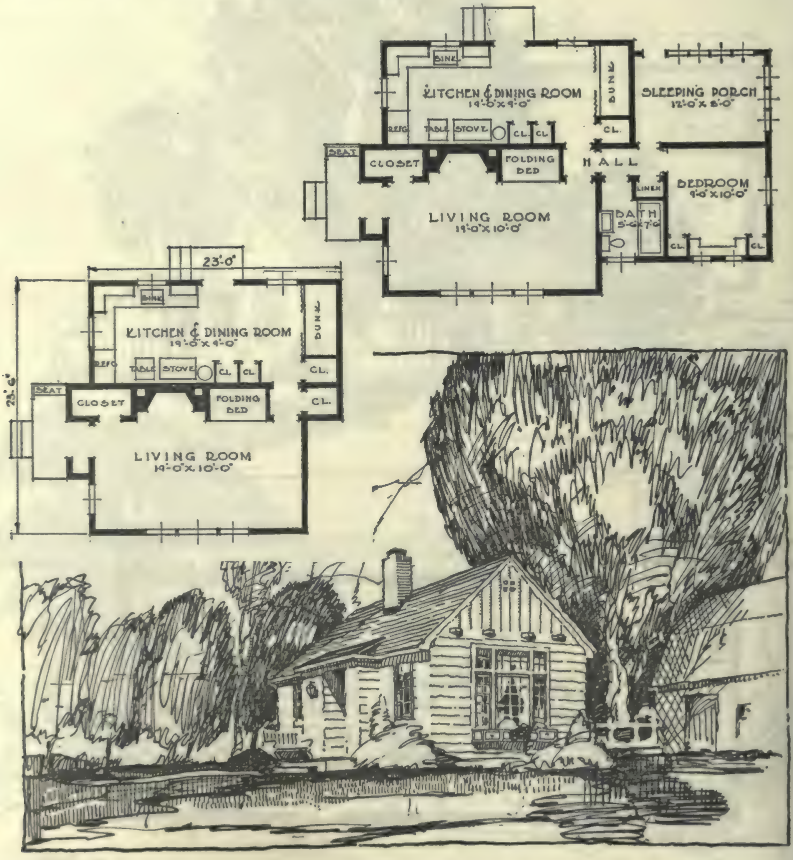
[34] Prepared by A. L. Matthews and N. G. Napier for the department of agricultural ngineering, University of Arkansas.

PLAN 6503[35]

Floor areas: Superstructure, original house 520 square feet; with addition, 825 square feet.

Small homes are often cut up into several rooms, with the result that in them a person has a "boxed-in" feeling. In plan 6503 the rooms are few, and each is used for more than one purpose. If the cost must be kept to a minimum, the bedroom and sleeping porch may be omitted in the original construction. The kitchen-dining room is unusually large for a house of this size, and the equipment is grouped in the front part of the room where the housewife can have a good view of the highway.

When the bedroom and sleeping porch are built, the bunk in the kitchen-dining room may be taken out to provide more dining space; or if one desires a cellar under part of the house, the cellar stairway may replace the bunk space. A large window and high-beamed ceiling are features of the living room. The chimney must not be too small; it is a feature of the house.



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[35] Prepared by R. A. Deal and W. W. DeNeff for the department of agricultural engineering, State College of Washington.

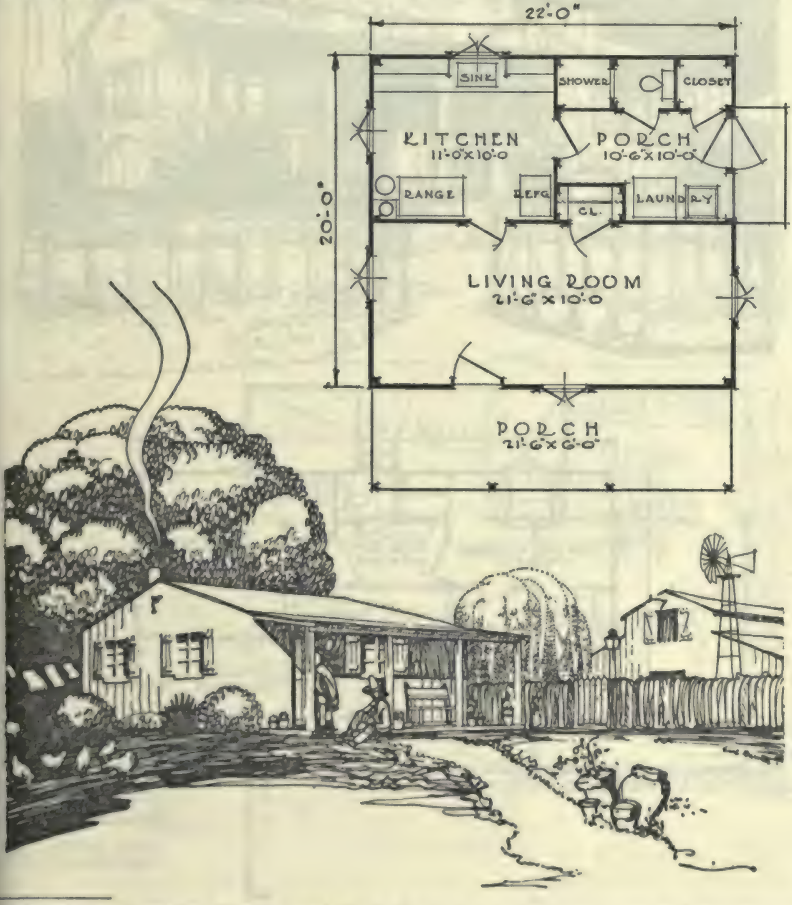
PLAN 6504,[36] FOR THE SOUTHWEST

Floor areas: Superstructure, 430 square feet. Porches, 145 square feet.

Plans 6504 and 6505 were designed for the central valleys of California, where outdoor sleeping is invited by the mild nights.

These were designed for temporary homes to be used later as shops, bunk houses, storage buildings, or for other uses, so concrete floors are recommended. Low-cost "frameless" construction is shown in the working drawings. There are no ceilings. The shower baths shown in the plans can be installed cheaply.

The kitchens and work porches are large enough for the needs of a good-sized family. Plenty of windows are provided for ventilation. The kitchen arrangement shows a wood-burning stove, and a large refrigerator placed against an inside wall for protection from the outdoor heat. It is expected that meals will ordinarily be eaten in the kitchen or outdoors.



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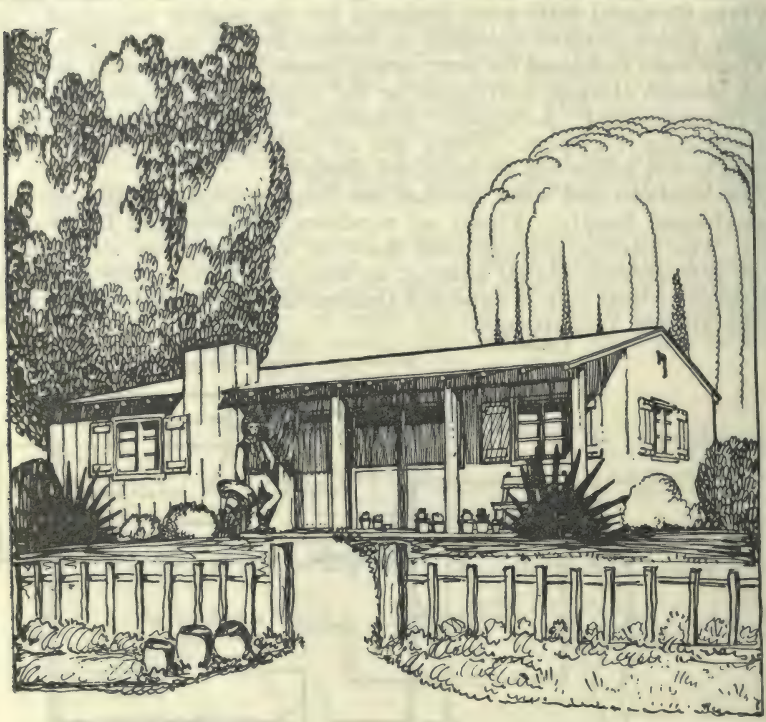
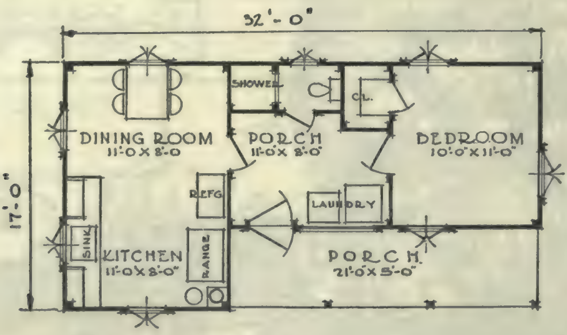
[36] Prepared by W. K. Bartges and Earl Barnett for the department of agricultural ngineering, University of California.

PLAN 6505,[36] FOR THE SOUTHWEST

Floor areas: Superstructure, 410 square feet. Porches, 125 square feet.





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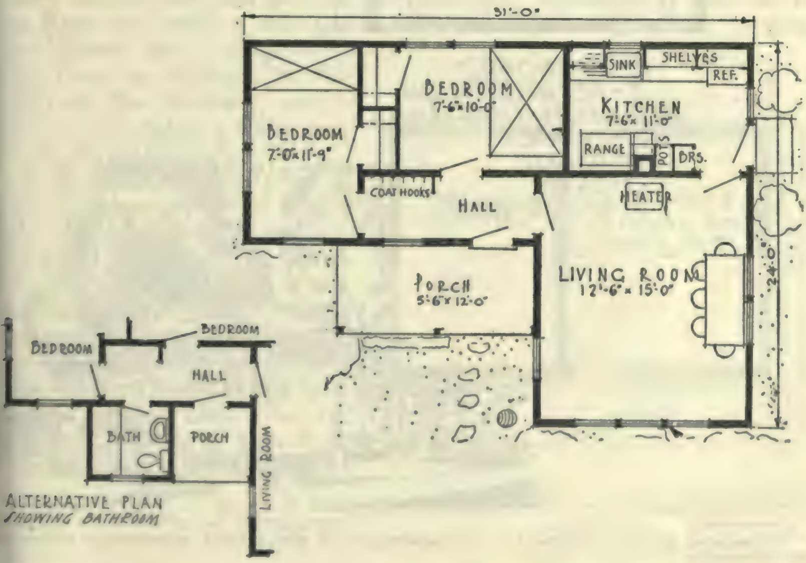
[36] Prepared by W. K. Bartges and Earl Barnett for the department of agricultural engineering, University of California.

PLAN 6506,[27] FOR NEW ENGLAND

Floor areas: Superstructure, 540 square feet. Porches, 60 square feet.

Though the rooms in plan 6506 have been kept as small as possible in order to reduce cost, good use of space is realized in the arrangement. Additions to the house would enable it to accommodate an average-sized family.

A work-porch addition beside the kitchen and living room, between the windows, would provide a place for laundry work and for hanging outer wraps. A bathroom might be built by enclosing a portion of the front porch and enlarging the window to make a doorway from the hall. If desired, a third bedroom could be added at the end of the living room.



ALTERNATIVE PLAN
SHOWING BATHROOM

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[27] Prepared by Bernhard Dirks for the department of agricultural engineering, Massa- husetts State College.

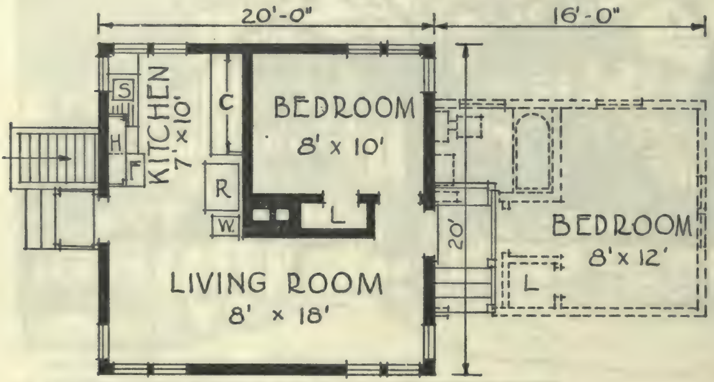
PLAN 6507,[38] FOR THE NORTH

Floor areas: Superstructure, original house, 380 square feet; with first addition 600 square feet. Porches and entrances, 50 square feet. Cellar, first unit 380 square feet; with addition 600 square feet.

Plan 6507 is intended for snowy sections, and the first floor is purposely raised above the winter snow level. The house can be built in either one or two stages.

No partition divides the kitchen and living room, which permits heating the house with the kitchen range in mild weather. It also aids ventilation in summer and facilitates serving of meals in the living room.

The steps to the cellar are outside the house, protected by a storm door. There is ample space in the cellar for laundry and storage. A cistern under the kitchen provides soft water.



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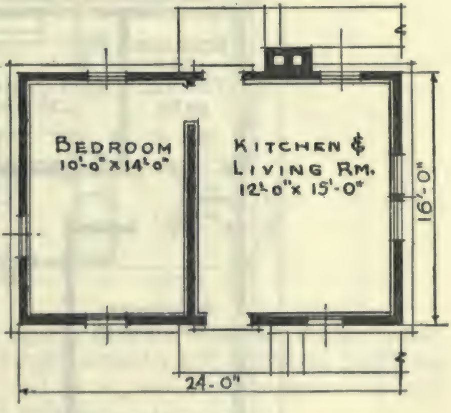
[38] Prepared by S. A. Witzel for the department of agricultural engineering, University of Wisconsin.

PLAN 6508,[39] FOR THE NORTHWEST

Floor areas: Superstructure, first stage 385 square feet; second stage 605 square feet; third stage 755 square feet. Porches and steps, first stage 20 square feet; second and third stages 70 square feet.

This house is designed for the minimum requirements of beginners on the land, the first portion being 16 by 24 feet outside. It may either be enlarged for a permanent dwelling or later used as a service building. The bedroom is ample in size, but the living room, because it must also be used temporarily as a kitchen and dining room, will be crowded. This unit may be made 18 feet instead of 16 feet wide. Later the kitchen and a small bedroom may be added at the rear of the first unit, with a side porch off the kitchen. The door between the kitchen and living room will then be changed to the right of the chimney, and a narrow hall taken off the rear of the front bedroom.

If an additional bedroom is desired, it can be added to the left of the bathroom, making the third stage for this house. The closet in the kitchen should be removed and a door cut through to allow easy access from the kitchen to the bath and bedrooms. The bedroom closets must be rearranged to allow for these changes.



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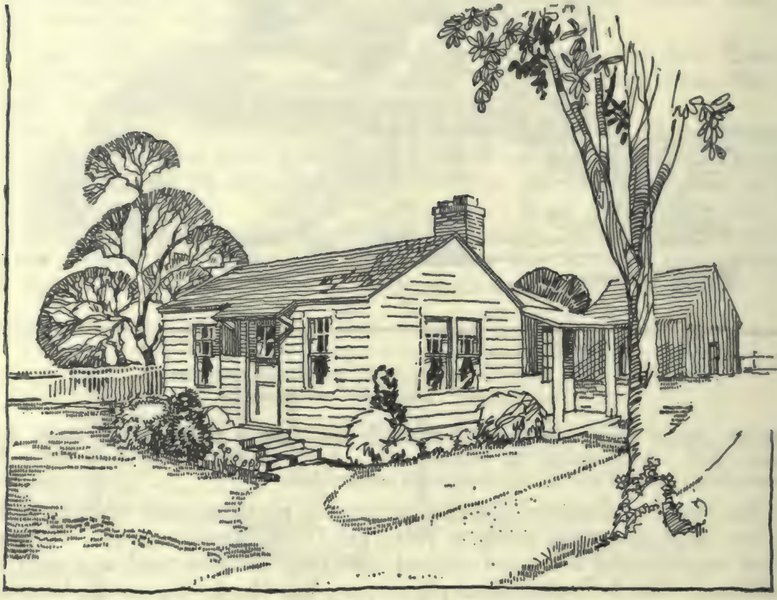
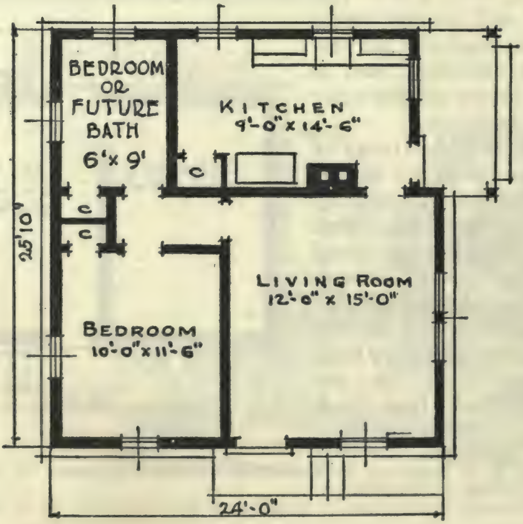
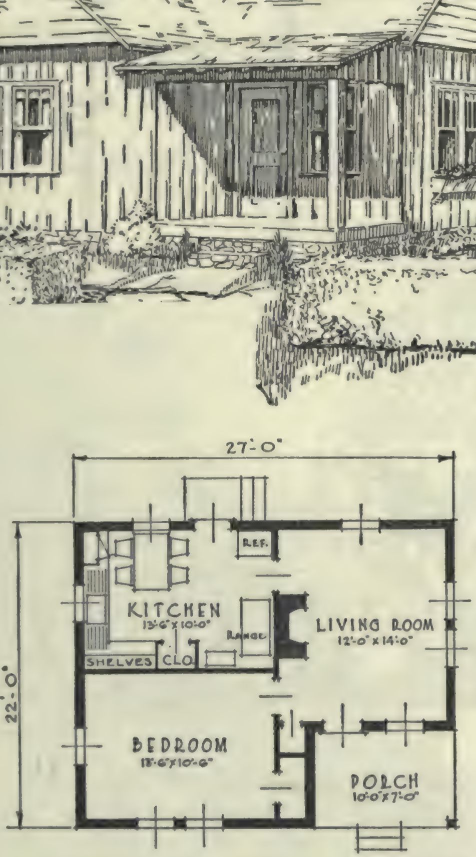
[39] Prepared by R. A. Deal and W. W. DeNeff for the department of agricultural engineering, State College of Washington.




BEDROOM OR FUTURE BATH
6'x 9'
KITCHEN
9'-0" x 14'-6"
C
C
C
LIVING ROOM
12'-0" x 15'-0"
BEDROOM
10'-0"x11'-6"
25'10"
24'-0"

PLAN 6509,[40] FOR THE SOUTH

Floor areas: Superstructure, 525 square feet. Porches and steps, 90 square feet.



Plans 6509 and 6510, for the South and the Middle West, respectively, are low-cost houses for families that need only one bedroom. The kitchens are well arranged and have good storage space. Closet space also is ample for houses of this size.

A storage and work room, as shown in plan 6510, is a good feature for the North but is not so much needed in the South, where mild

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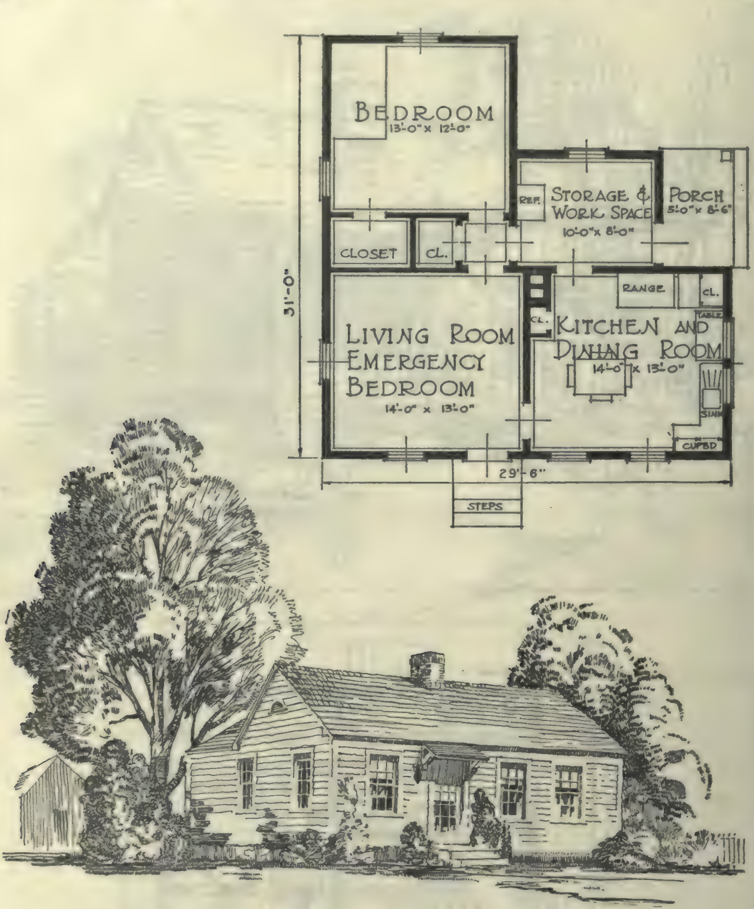
[40] Prepared by W. C. Breithaupt and H. W. Dearing for the department of agricultural engineering, Alabama Polytechnic Institute.

PLAN 6510,[41] FOR THE MIDDLE WEST

Floor areas: Superstructure, 740 square feet. Porches and steps, 60 square feet.



weather permits doing much housework outdoors. The living-room fireplace and kitchen range should heat house 6509 comfortably under ordinary southern conditions, but in the North arrangements should be made for a stove or circulator heater as in plan 6510.

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[41] Prepared by H. J. McKee and Arthur Wupper for the department of agricultural engineering, University of Illinois.

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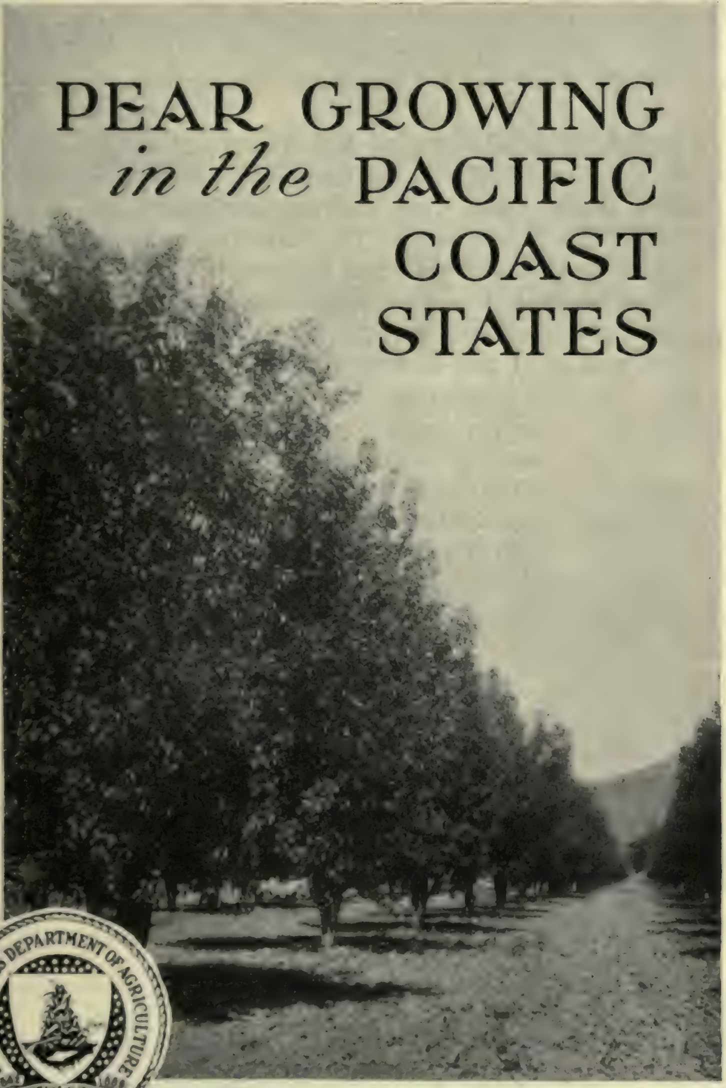
U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1739

PEAR GROWING *in the* PACIFIC COAST STATES



THE PEAR is one of the important deciduous fruit crops of the Pacific coast. Pear growing there dates from the earliest settlement of the country by white men. The varieties grown have largely been imported from Europe.

This bulletin describes the methods of commercial pear growing in the Pacific Coast States, and includes descriptions of the principal varieties, soil-management practices, pruning, and general orchard care. Rootstocks for orchards, the fertilizer requirements of the pear, and pollination of the commercial orchards are discussed. The characteristics of the important pear districts are described in detail. A general picture of production practices and of the present status of the pear industry is presented.

Washington, D. C. Issued January 1935

PEAR GROWING IN THE PACIFIC COAST STATES

By C. F. **Kinman**, *pomologist*, and J. R. **Magness**, *principal pomologist*, *Division of Fruit and Vegetable Crops and Diseases, Bureau of Plant Industry*

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INTRODUCTION

IN THE UNITED STATES the pear reaches a very high degree of perfection in the States west of the Rocky Mountains; production is especially heavy in the three coast States. The varieties grown are almost exclusively those of high quality introduced from Europe. The pear districts are characterized by dry summers with abundant sunshine. Under these conditions fruit production reaches the maximum, yields as high as 30 tons of fruit per acre being sometimes secured in the better orchards. The fruit produced is also of high quality for the variety. The bacterial disease known as “pear blight”, which limits the production of pears to varieties partially resistant to it in most parts of the United States, can be controlled sufficiently to permit the growing of the choicest varieties in that section.

The pear takes fourth place in importance among the deciduous tree fruits of the Pacific slope, only the apple, peach, and plum ranking above it. Like the other fruits, it has ranked among important commercial fruit crops here for the past half century or more, or since soon after this region began to be generally and extensively developed.

Along with olives, figs, grapes, and other hardy fruits, pears were one of the important crops of the Franciscan monks, who imported them from Europe and planted and cultivated them at the various California missions. This work of the missionaries antedates the second epoch in the history of the pear industry by nearly a century.

Only remnants of these orchards, which produced fruit that is considered to be of inferior quality at present, have withstood the neglect to which they have been subjected since the missions were secularized.

The second epoch in pear production started when fruit growing became an important commercial industry in a number of sections of the West, which in California was in the middle of the past century. The general development of this section started about that time. About 20 years later, commercial shipments were made in carload lots. Numerous small pear orchards were established in Oregon and Washington during pioneer days from 1850 to 1880, but the industry did not reach commercial proportions until early in the present century.

CLIMATIC REQUIREMENTS OF THE PEAR

Although the pear will endure a wide range of climatic conditions, its culture for the most part has been restricted to localities that are particularly favorable for pear production. On the Pacific coast the pear is an important commercial crop from south-central California to the Canadian line and on up into British Columbia. The southern limit of commercial pear growing is determined by the prevalence of high winter temperatures. In common with the peach, apple, and other deciduous fruits, the commercial pear varieties grown on the Pacific coast require a considerable period of low temperatures during the winter months to cause them to start off vigorously in the spring. Consequently the pear is not adapted for commercial production in regions where winter temperatures are so mild that the trees do not become completely dormant.

Most varieties of pears will endure relatively low winter temperatures without much injury. If the trees are fully dormant, temperatures as low as −20° F. usually will do little injury. The wood and buds of the pear are apparently somewhat more subject to injury from low temperatures than are those of apples under the same conditions. On the other hand, the pear is somewhat more resistant to low temperatures than is the peach. In general, pear planting would be considered questionable where temperatures lower than −20° to −25° F. are likely to occur.

In most of the Pacific coast districts irrigation is depended upon for moisture supply, the main exceptions being in northwestern Oregon and western Washington; consequently, rainfall does not determine the distribution of pear production. Observations would indicate that where natural rainfall is depended upon for soil moisture, an average of at least 35 inches per year is desirable.

Of extreme importance in the location of a pear orchard is the question of air drainage and freedom from spring frosts. The pear is a relatively early bloomer. If it has become completely dormant during the winter it normally blooms several days earlier than apples. The blossoms are about as easily damaged by spring frosts as are those of apples and peaches; thus the hazards from spring frosts are greater with pears than with apples, due to the earlier blooming season. In many parts of the Pacific coast it has been found desirable to equip pear orchards with heaters to protect the trees during the blooming season, particularly where orchards are located on lowland where air drainage is not especially good. Because of the adaptability of the pear to fairly heavy soils, orchards have frequently been located on lowland.

The most serious disease factor in connection with pear production is pear blight, caused by the bacterium *Bacillus amylovorus*. On the Pacific coast this disease is most serious in the interior valleys, particularly those of California and southern Oregon, where spring and early summer temperatures are likely to be high. In districts having cooler growing seasons, such as the coastal districts of California, the Willamette and Hood River Valleys of Oregon, and the Puget Sound district of Washington, pears are much less seriously affected by this disease.

Treatments for the disease are primarily surgical. Cutting out affected branches and disinfecting the wounds are common practices in all pear-growing regions. New methods for control are being continually studied. Detailed directions for handling the disease can be obtained from county agents or State experiment station workers in the different districts.

Apparently there is a very definite correlation between climatic conditions and the quality of certain varieties. The Bartlett, which is by far the most important pear variety on the Pacific coast, apparently reaches its highest dessert quality and best shipping and storage quality where temperatures for the 2 months preceding harvesting are high. Grown in the cooler districts, this variety generally tends to ripen relatively quickly after picking and has a marked tendency to break down at the core while still firm and in prime eating condition on the outside. Fruit of this variety grown in hot districts, on the other hand, tends to ripen somewhat more slowly after harvest, remains in prime eating or canning condition for a longer period, and has less tendency to break down at the core while the outside is in good shape. The Bosc, another important variety, also appears to reach its highest dessert quality under relatively high temperature conditions. Other varieties, including Anjou, Hardy, Winter Nelis, and Easter Beurre, are well adapted to cooler conditions and appear to reach equally good quality in the cooler climate of the coastal districts of California and the moderately hot valleys of the Northwest.

The mean summer temperatures at typical points in important Pacific coast pear districts are shown in table 1.

TABLE 1.—*Mean growing-season temperatures, by months, in important pear-growing districts in the Pacific Coast States*

Station	District	Mean temperatures (°F.)						
		March	April	May	June	July	August	September
San Jose	Central California, coastal	53. 1	56. 3	58. 5	62. 7	66. 5	66. 1	64. 2
Santa Rosa	do	51. 2	54. 4	57. 6	63. 0	65. 2	64. 4	63. 8
Auburn	Central California	51. 2	56. 1	62. 4	71. 4	77. 0	76. 0	69. 2
Marysville	do	54. 3	59. 4	64. 8	72. 8	77. 8	76. 2	71. 9
Sacramento	do	54. 3	58. 1	63. 3	69. 4	73. 2	72. 9	69. 3
Upper Lake	do	49. 9	54. 8	59. 6	66. 7	73. 8	72. 7	66. 7
Fairmont	Antelope Valley, Calif.	52. 1	57. 0	63. 9	72. 3	80. 9	79. 8	73. 0
Medford	Rogue River Valley, Oreg.	46. 7	51. 6	57. 7	65. 2	71. 8	70. 8	63. 1
Salem	Willamette Valley, Oreg.	46. 3	51. 0	56. 1	61. 6	66. 6	66. 7	60. 9
Hood River	Hood River Valley, Oreg.	43. 3	49. 9	56. 1	61. 6	67. 4	66. 6	59. 5
Wenatchee	Wenatchee Valley, Wash.	42. 8	51. 5	58. 8	66. 2	73. 2	71. 6	61. 6
Yakima	Yakima Valley, Wash.	44. 1	52. 5	59. 0	66. 4	71. 4	69. 5	61. 1
Puyallup	Puget Sound, Wash.	44. 8	49. 2	54. 2	59. 6	63. 8	62. 8	57. 7

SOILS FOR THE PEAR

The pear will apparently tolerate a somewhat wider range of soils than most orchard fruits. The trees will thrive on practically all orchard soils, provided they have sufficient moisture and are well drained. They will succeed better on the heavy, sticky clays and adobe soils than do almost any other of the commonly grown fruits. Like other fruits, they grow best on deep, fertile loams, and it is on such soils that most of the best trees are found. A clay loam with a well-drained subsoil is generally considered best for them.

Good tree growth cannot be expected on shallow soil of low fertility or on poor soil where the subsoil is water-logged. Good tree growth and production may be attained even where the water table is fairly high if the soil is fertile and if irrigation furnishes sufficient moisture during the dry summer season. Pear trees do well in the lower portion of the Sacramento River Valley, where the soil is built up by recent deposits of fertile silt loam and where there is movement in the subsoil water. In this district the water table is fairly high, but as it supplies moisture during the summer, the trees apparently thrive. On the other hand, the pear is not well adapted to soils having an impervious clay subsoil. Although pear trees thrive on somewhat heavier soil types than most other fruits, good drainage is essential to good growth and productiveness.

Where irrigation is not supplied it is particularly important that the soil be deep, well drained, and retentive of moisture. The summer season in all of the Pacific coast districts is relatively dry. Unless the soil has a good moisture-holding capacity the trees will suffer as they grow older, unless irrigation is practiced. With deep retentive soils and an abundance of winter rainfall, fairly good production can be secured without irrigation.

PEAR-GROWING DISTRICTS

Because of soil and climatic demands, most pear orchards in the Pacific States are found in restricted localities where the conditions for good production are well supplied. Numerous fruit crops besides pears are grown in these same districts, as crop diversification is desired. The prevalence of pear blight has prevented a more general distribution of pear growing in some sections. All three of the States bordering on the Pacific Ocean have a few important centers of pear production. and from these restricted areas come most of the shipments of this fruit. There are two important centers of production in both Washington and Oregon, and several in California.

For convenience in discussion, the principal pear-growing districts that are set off by natural geographic boundaries will be considered separately. These districts are widely separated, and each possesses peculiarities which make pear growing attractive. They are as follows: (1) Interior valleys of central California, including the smaller tributary valleys and adjacent slopes and foothills; (2) coastal districts of central California; (3) the plateau region of the south-central portion of California; (4) interior valleys of western Oregon; (5) the Hood River Valley; and (6) the Yakima and Wenatchee Valleys, of central Washington.

The acreage devoted to pears in the principal pear-growing sections is given in tables 2 to 6.

Outline maps of California, Oregon, and Washington (figs. 1 to 3) show the relative position of the pear-growing centers.

TABLE 2.—*Estimated acreage of pears in California by counties containing over 3,000 acres of pears, and total acreage for the State, 1932*[1]

County	Bearing trees	Non-bearing trees	Total	County	Bearing trees	Non-bearing trees	Total
	Acres	*Acres*	*Acres*		*Acres*	*Acres*	*Acres*
Sacramento	7, 480	1, 571	9, 051	Solano	3, 583	969	4, 552
Lake	7, 465	955	8, 420	El Dorado	3, 914	656	4, 570
Santa Clara	7, 308	513	7, 821	Napa	2, 625	400	3, 025
Placer	6, 482	1, 816	8, 298	Sonoma	3, 125	707	3, 832
Los Angeles	4, 037	71	4, 108	Other counties	15, 568	2, 213	17, 781
Mendocino	3, 457	2, 072	5, 529				
Contra Costa	4, 504	464	4, 968	Total	69, 548	12, 407	81, 955

[1] Compiled from acreage estimates, California fruit and nut crops, 1927 to 1932.

TABLE 3.—*Estimated acreage of principal varieties of pears in California*[1]

[Bartlett for 1932, other varieties for 1929]

Variety	Non-bearing trees	Bearing trees	Total	Variety	Non-bearing trees 1 to 5 years of age	Bearing trees over 5 years of age	Total
	Acres	*Acres*	*Acres*		*Acres*	*Acres*	*Acres*
Bartlett	9, 998	60, 078	70, 076	Comice	122	633	755
Anjou	152	754	906	Easter Beurre	580	369	949
Hardy	1, 294	1, 288	2, 582	Winter Nelis	928	1, 909	2, 837
Bosc	1, 151	848	1, 999	Others	404	836	1, 240
Clairgeau	70	659	729				
				Total	14, 699	67, 374	82, 073

[1] Compiled from acreage estimates, California fruit and nut crops, 1927 to 1932, and California Crop Report, 1928.

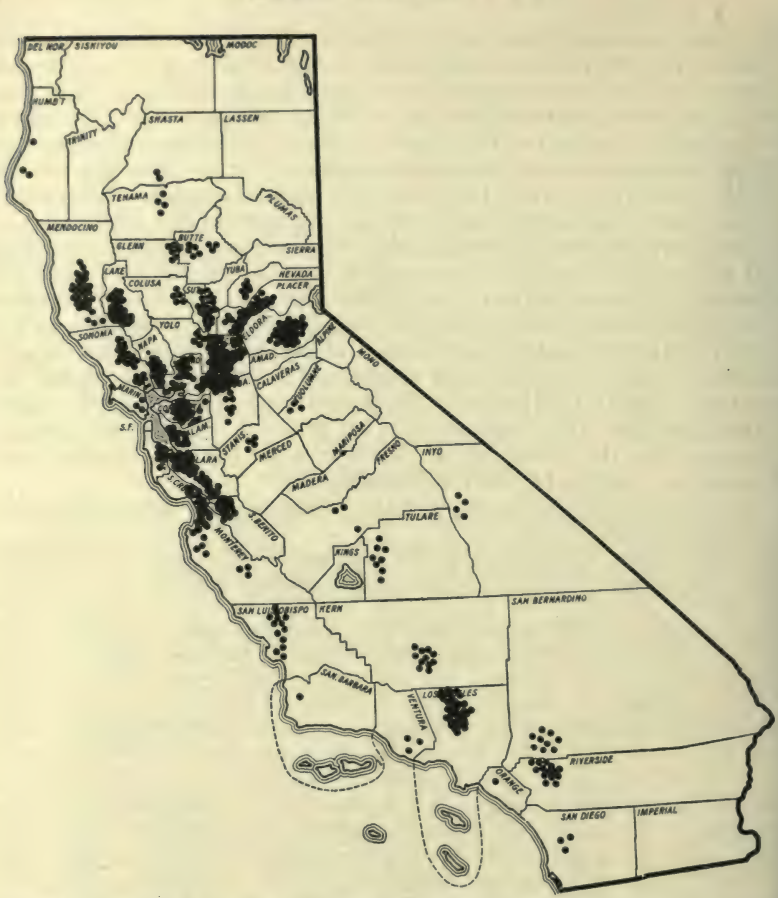

FIGURE 1.—Distribution of pear growing in California; each dot represents 100 acres of pears.

TABLE 4.—*Estimated acreage*[1] *of principal varieties of pears in Jackson County, Oreg. (the Rogue River Valley)*[2]

Variety	Trees 1 to 5 years of age	Trees 6 to 15 years of age	Trees over 15 years of age	Total	Variety	Trees 1 to 5 years of age	Trees 6 to 15 years of age	Trees over 15 years of age	Total
	Acres	*Acres*	*Acres*	*Acres*		*Acres*	*Acres*	*Acres*	*Acres*
Bartlett	625	904	2, 333	3, 862	Seckel	18	23	3	44
Anjou	680	606	1, 307	2, 593	P. Barry	9	33	9	51
Bosc	600	1, 283	1, 142	3, 025	Old Home, Kiefer, etc.[3]	100			100
Comice	73	209	457	739	Others	4	5	5	14
Howell	17	39	205	261					
Winter Nelis	173	229	540	942	Total	2, 299	3, 331	6, 001	11, 63

[1] Acreage calculated by dividing number of trees by 70.

[2] Compiled by the county agent from the fruit-acreage census of Jackson County, January 1932.

[3] Blight-resistant varieties used for top-working.

TABLE 5.—*Estimated acreage*[1] *of principal varieties of pears in Chelan, Douglas, and Grant Counties, Wash. (the Wenatchee Valley)*[2]

Variety	Trees 1 to 4 years of age	Trees 5 to 15 years of age	Trees over 15 years of age	Total	Variety	Trees 1 to 4 years of age	Trees 5 to 15 years of age	Trees over 15 years of age	Total
	Acres	*Acres*	*Acres*	*Acres*		*Acres*	*Acres*	*Acres*	*Acres*
Anjou	566	465	432	1,463	Winter Nelis	2	13	27	42
Bartlett	1,054	1,017	740	2,811	Others	8	10	29	47
Bosc	192	287	16	495					
Flemish Beauty	196	203	47	446	Total	2,018	1,995	1,291	5,304

[1] Number of trees divided by 70 to secure acreage.
[2] Compiled from 1931 orchard census, made by the district horticultural inspector.

TABLE 6.—*Estimated acreage*[1] *of principal varieties of pears in Yakima and Kittitas Counties, Wash., in 1931*[2]

Variety	Trees 1 to 5 years of age	Trees 6 to 14 years of age	Trees 15 years of age and over	Total	Variety	Trees 1 to 5 years of age	Trees 6 to 14 years of age	Trees 15 years of age and over	Total
	Acres	*Acres*	*Acres*	*Acres*		*Acres*	*Acres*	*Acres*	*Acres*
Anjou	390	335	428	1,153	Winter Nelis	214	795	1,328	2,337
Bartlett	2,975	6,363	4,375	13,713	Others	18	38	95	151
Bosc	536	770	46	1,352					
Flemish Beauty	168	347	25	540	Total	4,301	8,648	6,297	19,246

[1] Acreage calculated by dividing number of trees by 70.
[2] Orchard census, Yakima and Kittitas Counties, 1931, by Wendell P. Brown, horticultural inspector, Washington State Department of Agriculture.

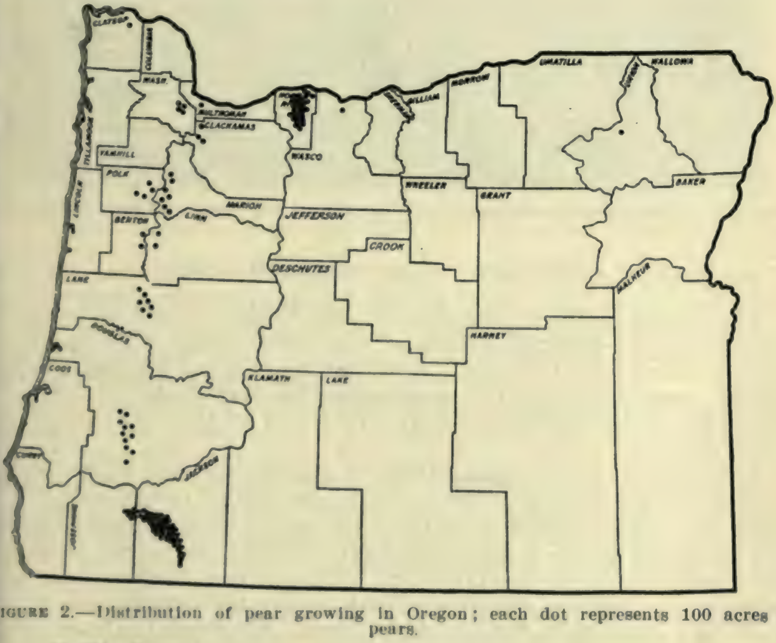

FIGURE 2.—Distribution of pear growing in Oregon; each dot represents 100 acres of pears.

THE INTERIOR VALLEYS OF CENTRAL CALIFORNIA

Pear culture in the interior valleys of central California is mainly restricted to a few localities, although scattered commercial orchards and occasional home-orchard trees are found throughout almost the entire territory. Over one-third of the pear trees in California are growing in this district. The principal pear-producing sections here include (1) the bottom lands of the Sacramento Valley, (2) the foothills to the east of the Sacramento Valley, (3) the valleys to the northwest of the lower portion of the Sacramento Valley, and (4) the Clearlake section of Lake County and the Ukiah section of Mendocino County. All these are important pear-producing sections, and all are well adapted to the production of the Bartlett variety.

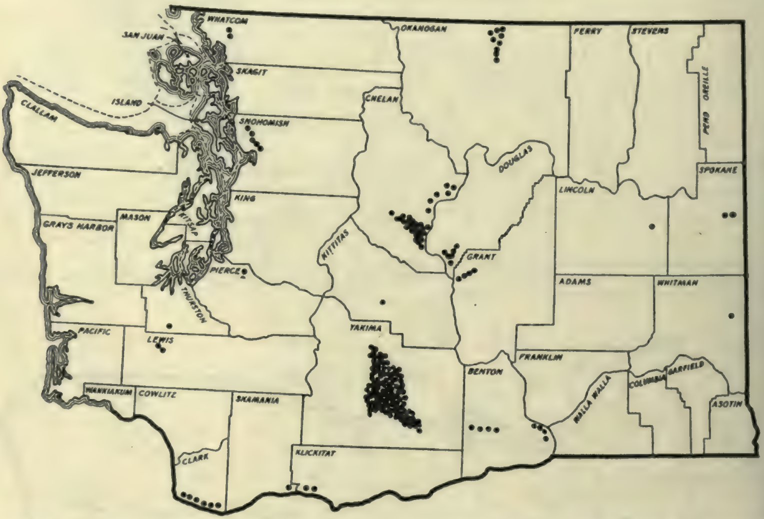

FIGURE 3.—Distribution of pear growing in Washington; each dot represents 100 acres of pears.

BOTTOM LANDS OF THE SACRAMENTO VALLEY

The bottom lands of the Sacramento Valley constitute the most important pear-growing locality of the Pacific slope, with over 9,000 acres in Sacramento County. Between the cities of Sacramento and Isleton, pear culture is the most important fruit industry. Practically all the trees of this county are found in the region near the river (fig. 4).

The soils devoted to pear culture in the Sacramento River bottom section for the most part are sedimentary and of recent origin. In some places the overflow from the river has added to the depth of the soil since the early orchards were established. In recent years the construction of levees has prevented the river from overflowing. The land in this locality, which was built up by the overflowing of the river, is a dark, open, friable, warm loam. Contrary to the belief of some that only heavy soils are suitable for pears, the Bartlett, which is grown almost to the exclusion of other varieties, reaches a high degree of excellence here both for dessert and for canning purposes. The soil becomes shallow as the lower portion of this section is approached and also as the distance from the river channel increases. This condition prevails also along the numerous slews that depart from the river and meander through the adjacent lowlands. As these slews reunite with the river or with one another, numerous islands are formed. In many places in this section, known as the "Sacramento delta or island district", the soil is too shallow for more than a fringe a few tree rows wide along the river or slews, though at other points the depth of soil permits of extensive orchards (fig. 5).

Beneath the stratum of fertile alluvial soil in this delta region is a bed of peat ranging from a few to many inches in thickness. Water passes through this material rapidly, and it therefore affords excellent drainage for the higher lands. On the other hand, artificial drainage must be provided for the lower land at the center of the islands; this is accomplished by digging large open ditches. One ditch may provide drainage for a wide area, because of the ready movement of the subsurface water.

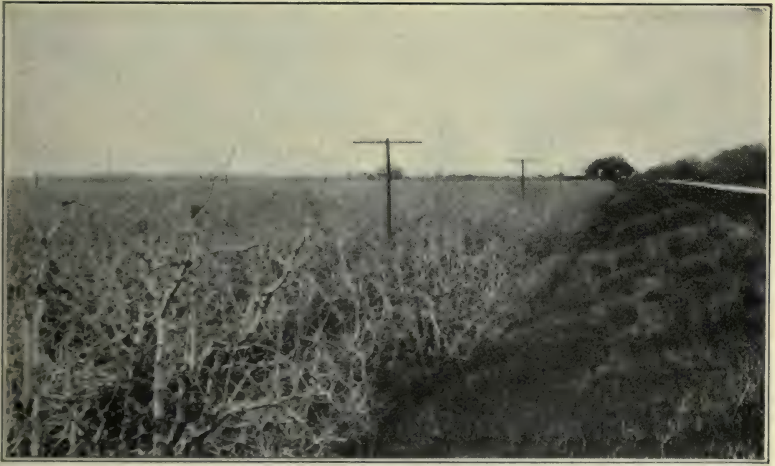

FIGURE 4.—A typical pear-orchard scene in the lower Sacramento River Valley during the dormant season. A portion of the river levee may be seen at the right.

Cherries, peaches, plums, and other tree fruits are also found on the higher soils along the levees in this district and provide for the desired crop diversification. On the higher, deeper, better drained portions that border the river in the northern part of this section, hese crops become proportionately more important. All orchards of this section are equipped for irrigation. Water from the river s easily and cheaply secured by means of pumps beside the river and pipes through the river levee.

As in most other localities of California where pears are grown, he coldest weather brings frequent frosts but only occasional light freezes. A large portion of the pear-producing acreage of this locality lies within the area where summers are moderately hot, although tempered to some extent by cool breezes from San Francisco Bay.

Pears in this section mature early, the first Bartlett shipments from the State usually originating here. The first shipments normally are forwarded in late June or early July, and the fruit moves to eastern markets for approximately 6 weeks. A large proportion of the late-harvested fruit is canned.

THE FOOTHILLS EAST OF THE SACRAMENTO VALLEY

In the second portion of the interior valleys of central California, the foothills east of the Sacramento Valley, most of the pears are found in Placer, Eldorado, and Nevada Counties, with centers in the Newcastle-Auburn section of Placer County, near Placerville in Eldorado County, and in the Grass Valley-Nevada City section of Nevada County. More than 13,000 acres are planted to pears in these districts, over four-fifths of which are of bearing age. All of these sections are in the rolling foothill region, the highest reaching an elevation of about 3,500 feet. The Bartlett is grown almost exclusively. This variety reaches a high degree of perfection for dessert purposes and attains a more colorful red blush than is common in the other pear-growing districts. It carries well to market but is usually smaller than the best pears from orchards on the deep soils of the river bottoms. The flesh is also firmer and is not considered as desirable for canning purposes. The harvest, especially at the higher elevations, is considerably later than in the river bottom, where the heaviest shipments originate, therefore fruit from

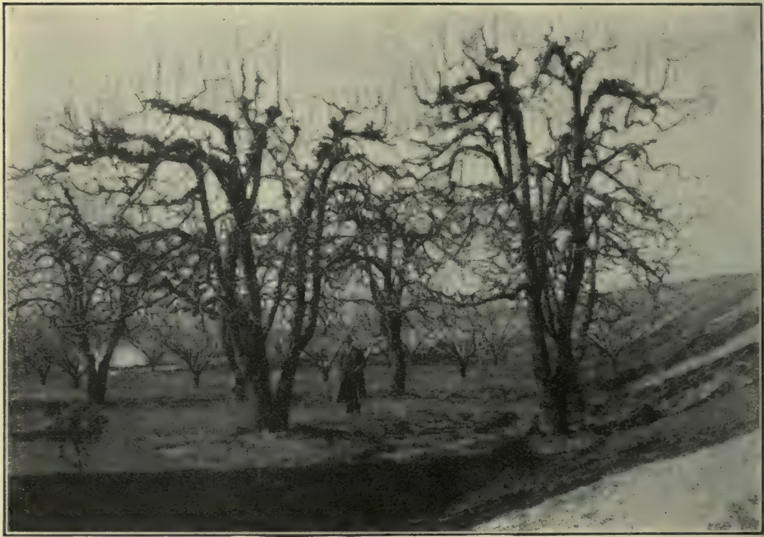

FIGURE 5.—Old Bartlett trees in the lower Sacramento River Valley. Much of the annual growth has been removed by pruning during the winter. The river levee may be seen at the right.

these higher elevations has an advantage in arriving on the market after peak shipments are past. The trees in these localities for the most part are not large, and the yield is not as heavy as on the deep bottom lands. Due to the late ripening of the fruit and its high shipping and dessert quality and excellent appearance, practically all of the output is shipped fresh. All orchards here are under irrigation.

Much of the soil in this section is derived from the weathering of granite bedrock and is open, easily worked, fertile, and well drained, but low in organic matter. It is several feet in depth in some places, but in others it is shallow, and outcroppings of granite are common. The drainage water from the higher soils accumulates at low levels following rains and irrigations, and causes areas varying in size from those large enough for but a few trees to those of several acres in extent where the soil water is too excessive for the satisfactory growth of most orchard trees. Many of these places are planted to pears; in others, especially in the higher regions, pear growing is the main industry, and there the deepest and best soils are used for this purpose.

In the higher localities the summers are hot, but somewhat shorter than along the Sacramento River or the sections lower in the foothills, and the pear blossoms are sometimes injured by frost. The blossoms open later in the spring, and the fruit-ripening time comes later in the summer than in the river section. It is here, however, because of the elevation that the excellent coloring of the fruit occurs.

THE VALLEYS TO THE NORTHWEST OF THE LOWER PORTION OF THE SACRAMENTO VALLEY

A third portion of the interior valleys of central California includes the Vaca and the Capay Valleys, northwest of the lower Sacramento River Valley. The district near Fairfield, in Solano County, although belonging to this geographical section, could be included in the coastal district, since the summer temperatures there are more comparable to those of that district. The Bartlett is the principal variety, and most of the fruit is shipped fresh. There is but little water available for irrigation. In the Vaca Valley, the principal center of production of Solano County, the summers are hot and advance rapidly, and the pears are among the earliest shipped from California. The soil there is a very deep, fertile, friable loam, and the trees are thrifty, but on account of lack of moisture they do not make a rapid growth, and the tonnage of fruit produced is only moderate. This tardiness of growth provides unfavorable conditions for pear-blight development. Some of the pear orchards are old, and there are but few new plantings, as most of the available orchard lands in this valley have been planted.

In the nearby Capay Valley, a small plateau in the Coast Range, about 1,000 feet above the lower portion of the Sacramento Valley, there are a few old orchards and a number not yet in bearing. The soil is heavy, and there is no water available for irrigation. Pear blight is not a serious factor here. The crop is later in ripening than in the lower, hotter Vaca Valley, and the fruit develops a higher color.

THE CLEARLAKE SECTION OF LAKE COUNTY AND UKIAH SECTION OF MENDOCINO COUNTY

The fourth center of production in the interior valleys of central California includes the Clearlake section about Kelseyville and Upper Lake, both in Lake County, and Ukiah in Mendocino County. Lake County has the second largest pear acreage in California, with over 8,000 acres. Mendocino County has over 5,000 acres, of which about three-fifths are of bearing age (1932). Near Clearlake there are a number of old orchards (figs. 6 and 7), but following the time of their planting the acreage devoted to pears increased only slowly until a few years ago, when there was a sudden expansion of the industry in this locality. With the improvement of the State highway over a mountain range connecting the Clearlake region with the railroad in 1920 came the general expansion of the pear industry. Previous to this time transportation was difficult and expensive, and but little fruit was shipped fresh.

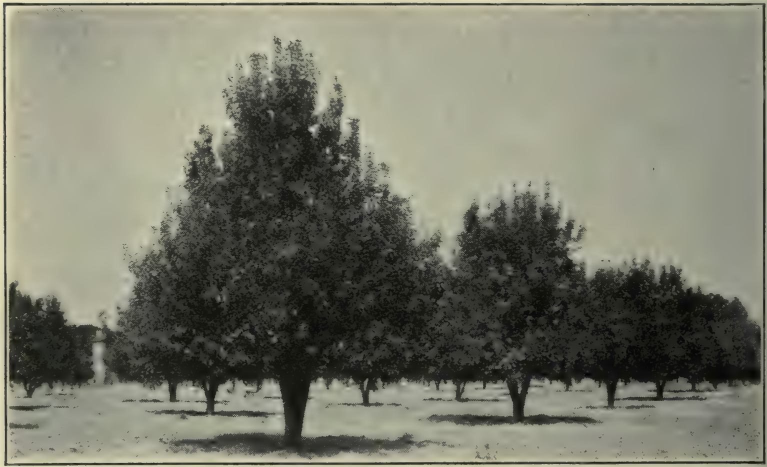

FIGURE 6.—A 40-year-old Bartlett orchard near Clearlake, Calif. The trees are 40 feet apart, and they produce heavy crops of fruit. Straw has been placed beneath the trees to prevent injury to the fruit that falls.

There is considerable variation in the soil in this locality. In some places it is a deep and easily tilled loam, but the larger areas are for the most part a rather heavy black clay that gradually slopes to the level of the lake. The soil is very fertile but should be worked only at the proper time. Until recently only a few orchards were irrigated, but now the practice is increasing. The water is secured largely from wells. The Bartlett is grown practically to the exclusion of other varieties. Trees grow well, bear regularly, and the fruit reaches large size and is of good quality and an attractive color. The trees blossom later and the fruit ripens later than in the principal sections of production in the Sacramento Valley. The fruit, therefore, reaches the market after the heavy shipments from that district have been sold. The high temperatures that prevail in the Clearlake region as the pear-ripening season is approached permit the fruit to attain excellent shipping quality.

Before the improvement of the State highway which connects this locality with the railroad, much of the pear crop was dried. The hot, dry summers are suitable both for maturing the fruit evenly so that it does not break down in the center upon ripening and for drying it in the open inexpensively. Owing to their large size and high quality, dried pears from Lake County are the standard of excellence for this product. With improved transportation facilities, a much larger portion of the crop is shipped fresh or goes to canneries, and the grower has these additional possibilities of disposing of his fruit.

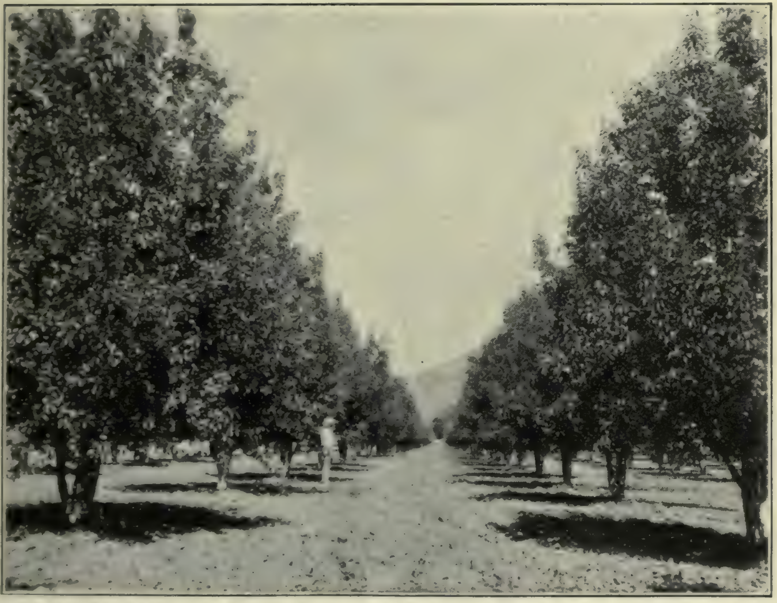

FIGURE 7.—An 18-year-old Bartlett pear orchard on deep, fertile, irrigated land near Kelseyville, Calif. (Photographed in June.)

THE VALLEYS OF CENTRAL CALIFORNIA LYING BETWEEN THE COAST RANGE AND THE PACIFIC OCEAN

The district lying between the Coast Range and the Pacific Ocean includes the counties adjacent to San Francisco Bay, Solano County, and also Monterey and San Benito Counties farther south. The principal pear-growing localities of this district are the low coastal plains adjoining San Francisco Bay in Santa Clara, Alameda, and Contra Costa Counties, the Napa Valley of Napa County, and the Sonoma Valley of Sonoma County.

In all these sections the temperatures are tempered by ocean breezes, so that the summers are much cooler than in the interior valleys. The lower summer temperatures are less favorable for the development of blight than those of the interior pear-growing districts. This also results in a later ripening period. In this district the Bartlett is of less desirable quality for distant shipment than in districts where there is a period of a few weeks of high temperatures previous to the fruit harvest. This is one of the oldest centers of commercial pear culture in California, and some of the orchards planted in the middle of the last century are still cultivated, though many of the varieties planted at that time have been grafted over to more desirable ones (fig. 8). At present there are more varieties grown commercially in this district than in other parts of California. They include the Bartlett, Hardy, Winter Nelis, Bosc, Anjou, Easter Beurre, Clairgeau, Comice, and others. Of late years the Hardy, Winter Nelis, and Bosc have been the most popular for planting. The Bartlett is grown mostly for canning, and the later ripening varieties for shipping fresh.

In the sections adjoining San Francisco Bay many of the pear orchards are at a low elevation and near the bay. The soil here is a dark, moderately heavy clay that is fertile but sticky when wet, and hard when dry. Care must be exercised to work it only when in proper condition. Farther back from the bay and on higher elevations the soil becomes more loamy and open and is well adapted to the culture of other deciduous fruits and nuts, and much of it has been planted to prunes, apricots, cherries, and Persian (English) walnuts. Occasional pear orchards have been planted on this more loamy land also, and such orchards generally have good tree growth and production. Practically all the orchards of this district are under irrigation. Santa Clara County ranked fourth in total pear acreage in California and third in bearing acreage in 1932.

Near San Juan and in the Carmel Valley, in Monterey County, the pear is the principal fruit grown, although the acreage is not large. In the former locality the soil is of a deep, fertile, and rather heavy type, and excellent tree growth and fruit production are obtained. The late-ripening varieties are grown almost exclusively, and the fruit is shipped fresh (fig. 9). The pear-growing center in the Carmel Valley is a narrow strip of river bottom land a few miles inland from the ocean. Late-ripening varieties are the principal ones grown. The soil is a deep, fertile, open loam, and trees thrive and bear well. Because of the small size of this valley, the land suitable for orcharding is very limited.

Throughout this coastal area, as well as in other southern regions in California, the Bartlett pears tend to lose their characteristic pyriform shape. Under extreme conditions the radial diameter of the fruit almost equals its length, and the fruit is not acceptable for canning. The cause of this condition is not known. There is some evidence that fruit on young vigorous spurs is longer than on old spurs from the same trees. Selection of long-fruited strains of Bartlett for such districts when propagating trees is to be recommended. This condition constitutes a serious problem in coastal districts where the crop is largely used for canning. Tufts and Hansen[1] have shown that fruit from the more northern districts averages longest in proportion to diameter, the ratios varying from below 1.2 to 1 in central California to 1.48 to 1 in Yakima, Wash.

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[1] TUFTS, W. P., and HANSEN, C. J. VARIATIONS IN SHAPE OF BARTLETT PEARS. Amer. Soc. Hort. Sci. Proc. (1931) 28: 627–633. 1932.

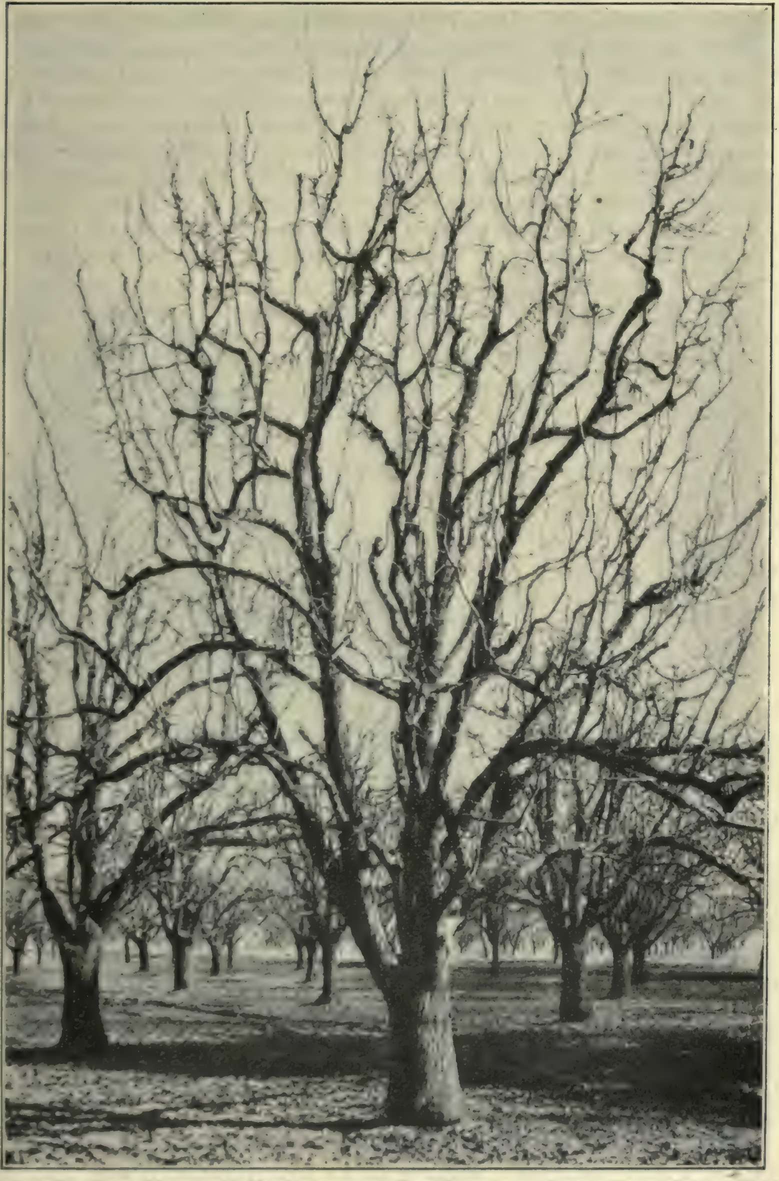

FIGURE 8.—Some 56-year-old Hardy trees on French roots. (Santa Clara, Calif. Photographed in February.)

THE PLATEAU DISTRICT OF SOUTH-CENTRAL CALIFORNIA

Since about 1910, more or less gradually, pears have been planted in the plateau district near the border of the Mojave Desert, Los Angeles County, with the principal center at Palmdale, where about 3,000 acres are now planted. This district lies at an elevation of about 2,500 feet above sea level. The summers there are very hot, but in winter the temperature is somewhat below that in most California pear-growing districts. The annual rainfall is very light, necessitating irrigation. The soil is rather shallow, has but little organic matter, but is open and friable. The Bartlett is practically the only variety grown, and most of the crop is shipped fresh.

In the western portion of San Bernardino and Riverside Counties, the principal pear-raising center of which is at Yucaipa, there are over 600 acres in pears, most of which are bearing. Most of this planting is of the Bartlett variety and has been made since water for irrigation became available about 15 years ago. The soil there is a reddish-brown clay loam, and good growth is secured when the orchards are irrigated and handled judiciously. The summers are very long and hot, and the winters are frequently so mild that the trees do not become sufficiently dormant for best production. Consequently, the district is not considered entirely desirable for pear growing. The fruit is used both for fresh shipment and for canning.

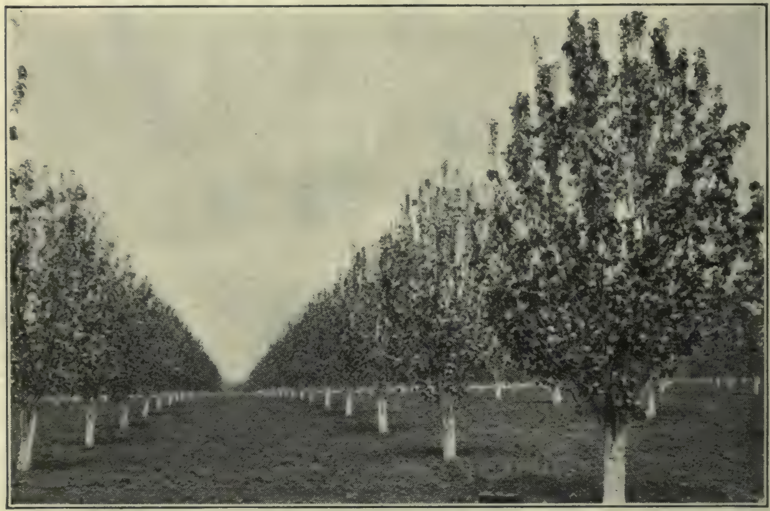

FIGURE 9.—A 10-year-old Hardy orchard near San Juan, Calif. The trees were planted 24 by 24 feet. They are on quince roots. (Photographed in April.)

In the nearby mountains there is a limited acreage of pears that produces fruit of excellent quality.

THE INTERIOR VALLEYS OF WESTERN OREGON

The principal pear plantings in western Oregon are found in the Rogue River Valley, and there are limited plantings in the Umpqua and Willamette River Valleys and their tributaries. The

Rogue River Valley district, lying west of the center of the State and almost touching the California line, is the principal center of production in Oregon, although the Hood River district is also an important producing center. The Rogue River Valley section ranges from 1,874 feet above sea level at Ashland on the south to 935 feet at Grants Pass on the north, and is almost entirely surrounded by mountains. The city of Medford, the principal shipping point, is situated near the center of this section. There are about 11,000 acres of pears in this locality. Large plantings were made early in this century, although about half of the present acreage has been planted since 1912. A considerable portion of the present acreage was planted after water for irrigation was made available between 1917 and 1920. The ravages of pear blight have been very severe in this valley.

Freezing temperatures occur throughout the valley in winter. Spring frosts are frequent, particularly on the floor of the valley, and orchards must be protected by heating, which is general and efficient. The lower slopes surrounding the valley are seldom visited by damaging frosts during blossoming time, owing to the good air drainage. The summers are hot and dry and well suited to the ripening of pears. The rainfall from September to the following May totals 15 to 25 inches per year and is supplemented by irrigation during the dry season in all but a small percentage of the orchards. Much of the soil of this district is a rather heavy adobe and is better suited to pears than to other tree fruits. Although the soil is fertile, much of it is underlain by a stratum of hardpan, at a depth varying from a few inches in some of the upland places to several feet in the bottom lands. In portions of the district, a high-water table presents a serious problem, requiring community drainage efforts. On the deeper soils trees grow rapidly; on the shallower ones wood growth is rather slow. The slow-growing trees are less susceptible to blight, but production is also much less.

Bartlett, Bosc, and Anjou are the varieties most extensively planted. Winter Nelis, Comice, Howell, and a few minor varieties are grown in commercial quantities also and range in importance in about the order named. While the Bartlett is still the most important variety, recent plantings have been largely of Bosc and Anjou. The Bartlett produced here is of high dessert and canning quality and ships well. Most orchards of Bartlett are in bearing. The Bosc blights badly there, but bears heavily, and the fruit is of good size, quality, and appearance. There are many new plantings of Anjou. The popularity of this variety is increasing, owing to its excellence in size, appearance, and dessert and storage quality. The Anjou tree is the most blight-resistant of the varieties extensively grown (fig. 10). The fact that the trees are late in coming into bearing and have generally been less productive than Bartlett and Bosc has prevented the planting of a much larger acreage. Winter Nelis has been a satisfactory variety where planted on the deeper soils and well irrigated, but in unirrigated orchards and on poor soils the fruit is often small.

In the Umpqua and Willamette River Valleys pears are grown commercially but are not included among the most important fruits. Summer temperatures in these valleys are lower than in the Rogue

River Valley and not warm enough for the best development of most pear varieties. With the lower temperatures of these valleys there is almost no loss from blight. Winter injury has at times been serious in the Willamette Valley, causing the loss of many orchards.

THE HOOD RIVER VALLEY

The Hood River Valley, which lies about 150 miles from the coast and at the extreme northern boundary of the State, is the only other district in Oregon where pear growing is an important commercial industry. There are about 2,500 acres devoted to this fruit, of which only one-third of the trees are of bearing age. Although the apple is the most important fruit grown in this district, pears are being planted more than apples at the present time.

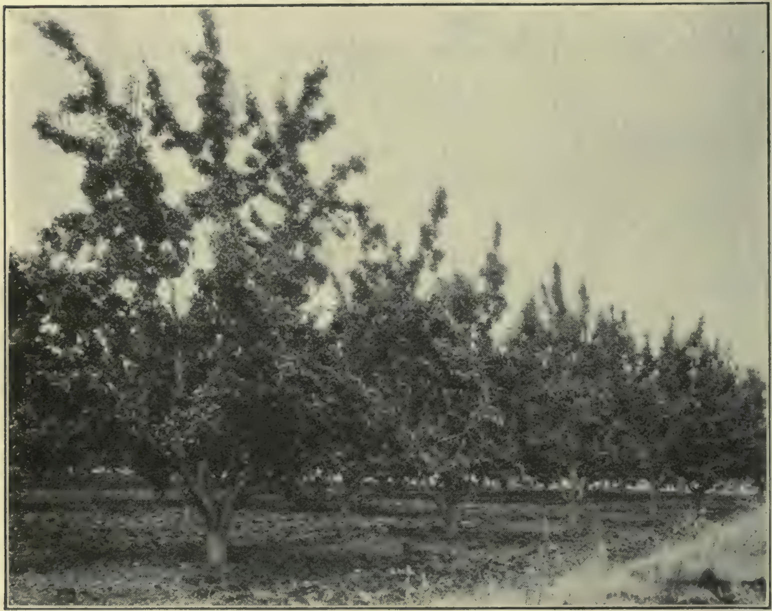

FIGURE 10.—A typical Anjou pear orchard on adobe soil in the Rogue River Valley, Medford, Oreg. (Photographed in July.)

Bartlett, Anjou, and Bosc are the principal varieties grown. Of the trees in bearing, a little over half are of the Bartlett variety, with Anjou, Bosc, Flemish Beauty, and minor varieties following in importance in about the order named. In the acreage not in bearing the Anjou leads in importance, probably half of this acreage being of this variety. There are approximately half as many acres of nonbearing Bosc as of Anjou, and new plantings of Bartlett are slightly less than those of Bosc. A few new plantings are found of the Easter Beurre variety, made because it is considered satisfactory as a pollinizer for Anjou. The popularity of the Anjou and Bosc is due to the high quality and appearance of the fruit, and their good keeping qualities when placed in cold storage. In this district the Bartlett is used both for canning and fresh shipment.

The soils of this district vary considerably in depth and texture, but not sufficiently to restrict the planting to given soil types, and pear orchards are found scattered throughout the fruit-growing portion of the valley. The surface soils are for the most part sandy or silty loam, very open, and in many places are rather shallow. Water passes through these soils rapidly. The subsoils are composed of about the same materials as the upper soils in many places; some of them are very open, permitting good or sometimes excessive drainage; others are so compact that the downward movement of water through them is almost entirely prevented.

The rainfall during the summer is very light, and this, with the rather poor water-holding capacity of the soil, makes irrigation necessary in most orchards. With the very open and well-drained soils in one locality and compact subsoils commonly known as hardpan in another, careful observation and caution are necessary in adopting a wise irrigation program. While pear roots will endure excessive soil moisture better than many of our tree fruits, they will not thrive in water-logged soils in summer. Therefore, where a hard substratum comes too near the surface, care in drainage is necessary to prevent an accumulation of seepage water from higher levels.

As the soil has a high sand and silt content and the surface layer suited to root growth is shallow in some places, there is need for increasing and maintaining the humus content. Cover crops, either cultivated plants or native vegetation, are grown for this purpose in most orchards. Alfalfa and sweetclover are the crops most commonly grown.

With the type of soil as described and the high rate at which succulent cover crops take water, there is likely to be a rapid change of moisture content in the soil, which requires special care to prevent drying out excessively between irrigations.

Winter injury constitutes a greater hazard to pear production in this district than in other important pear sections of the Pacific coast. Winters are generally mild, but occasional severe cold, with the trees not thoroughly hardened, has resulted in serious damage, particularly to young trees. Pear blight has not been serious in the Hood River Valley.

VALLEYS OF CENTRAL WASHINGTON

Two irrigated districts, one surrounding Yakima and the other centering about Wenatchee, are the only important pear-producing sections of central Washington. Pear orchards are found scattered throughout these large fruit-growing belts. In the older orchards, pears and apples were often interplanted. In both sections the soil is deep and fertile and well adapted to pear growing. As the rainfall is very sparse and occurs during the winter, all orchards are under irrigation. There is good tree growth and production in these sections, and blight, while troublesome in some years, apparently is not so severe a menace as in the Rogue River Valley and the interior valley sections of California. This, with the naturally good tree growth and production, makes pear growing attractive.

In the Yakima section commercial pear planting started about 1900, as did the commercial apple industry, but pear growing progressed slowly in comparison with that of the apple (fig. 11). About one-fourth of the pears, which total over 1,300,000 trees, were under 5 years of age in 1931.

Of the several varieties grown commercially in this district, the plantings of Bartlett are almost six times as extensive as those of any other. Winter Nelis comes next in number of trees planted with about four-fifths of them of bearing age. Of late years the interest in the Bosc and Anjou varieties has increased greatly. These varieties rank third and fourth in number of trees planted in this section, about one-half of those of each variety being in bearing. The acreage devoted to Flemish Beauty is considerably less than that of any of these varieties. About one-half of the Flemish Beauty trees are in bearing. Comice, which is the variety next in importance, has not been popular for planting of late years, and most of the trees are in bearing.

In the Wenatchee district, pears, with 371,409 trees in 1931, come next after apples in importance. There are nearly twice as many Bartlett trees as trees of any other variety, and more than half were over 5 years old in 1931. More than half of the Anjou trees were also over 5 years of age at that time. With the Bosc, which occupies third place in number of growing trees, less than half of the trees were 5 years of age in 1931. Flemish Beauty, the fourth variety in importance, has a little over half of the trees in bearing. Most of the small acreage of trees of the Winter Nelis variety are of bearing age, as this variety has been comparatively unpopular for planting during recent years. The new plantings of several varieties indicate the popularity of the pear as a commercial fruit in this section at the present time. In both the Yakima and Wenatchee sections the Bartlett attains good size, shape, and quality for canning. It is also shipped extensively. The variety reaches the extreme of pyriform shape or length in proportion to width in these northern districts. This long type of pear is very popular with canners.

With fertile, deep soil and abundant water for irrigation, pear trees in both the Yakima and Wenatchee sections are vigorous and productive. With abundant cold-storage facilities in the district, much of the Bartlett crop is held from 2 to 4 weeks in cold storage and is placed on the market after the California movement is over.

SITE FOR THE PEAR ORCHARD

From the standpoint of air drainage for frost protection, the slopes of rolling lands are preferable for pears; but for the purpose of crop diversification these places are often planted in California, at least, to fruits which blossom earlier than the pear and are therefore more susceptible to frost injury at blossom time. This leaves the lower places for the pear and sometimes makes artificial frost-prevention practices necessary. The slopes afford better soil drainage also, but here again the pear is more resistant to faulty growing conditions than are other fruits and will endure considerably more soil moisture provided such moisture is not stagnant and the soil is fertile. The pear likes a soil of good depth also, but will often succeed where the water table is too high for most other deciduous tree fruits. In the principal pear-growing districts of California and Oregon, a consid-

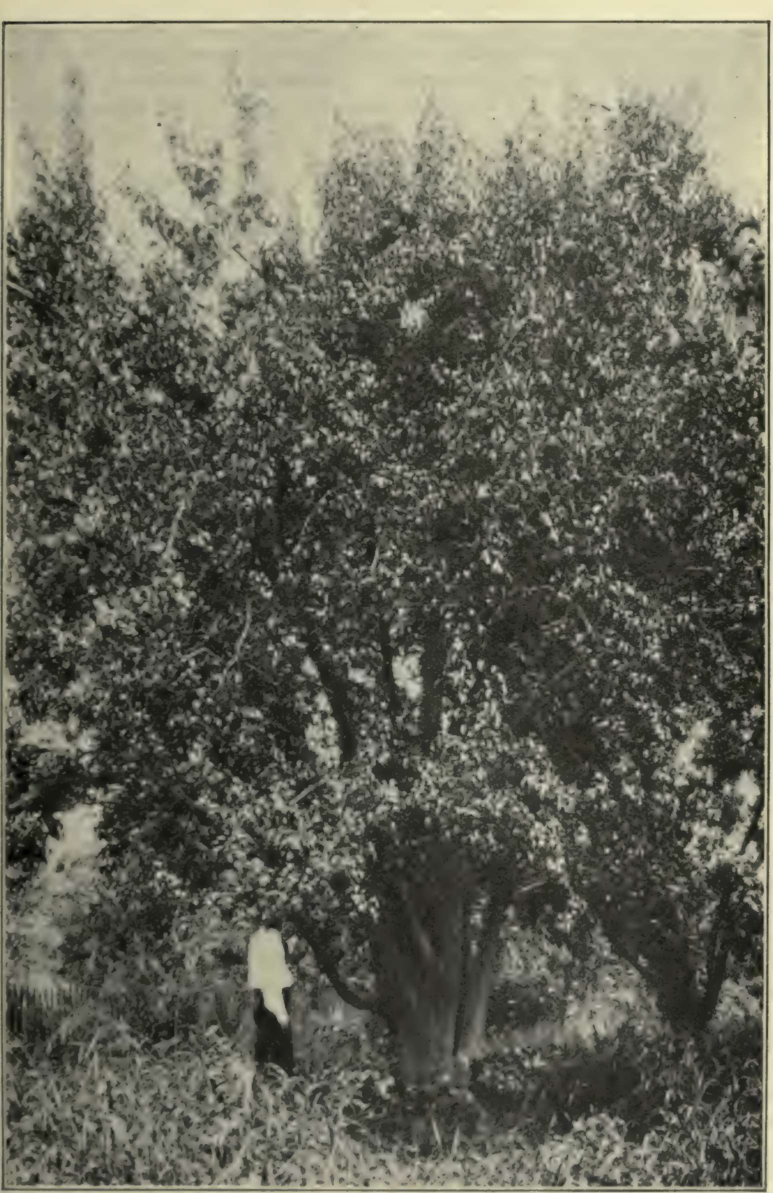

FIGURE 11.—Forty-year-old Anjou pear trees on deep, open soil in the Yakima Valley of Washington. (Sawyer, Wash.)

erable portion of the pear trees has been planted on sites where at least during the winter and spring the soil moisture is somewhat in excess of that considered ideal for the best tree growth.

As the pear fruit is easily injured in handling, the availability and condition of roads over which it may be taken to the packing house and shipping point are important. Fortunately, most of the pear-growing localities in the Pacific Coast States are well supplied with good roads.

STOCKS USED IN PROPAGATING PEAR TREES

The determination of the most suitable rootstocks for propagating pear trees has received a great deal of study. The most widely used stock is the European wild pear, *Pyrus communis*, commonly called French pear, and were it not for its susceptibility to pear blight, this stock would be almost ideal. It is a vigorous grower, withstands both drought and excessive soil moisture exceedingly well, and gives satisfaction on a wide variety of soils. In respect to its adaptability to a wide range of soils and climatic conditions, it is one of the most remarkable of cultivated plants. It is also considered one of the most resistant to oak-root fungus among those used for common fruit trees. This species is very susceptible to blight, however, and this disease is often disastrous to the orchard. The French root not only takes blight readily and proves to be an excellent medium for the development of the disease, but also tends to produce suckers, thereby providing a convenient entrance to the root for blight. The suckers often appear in large numbers, coming up well out under the branches, as well as near the trunk. It is the common practice to remove this growth each year, to reduce the chances for blight infection. Except where small trees for close planting are desired, the French stock, even with its susceptibility to the dreaded pear blight, appears to be the best stock now available for general planting and at the present time is being used almost to the exclusion of others.

For a number of years the Japanese stock, *Pyrus serotina*, was planted extensively, but for the past few years its popularity has been decreasing. It was chosen for its resistance to blight and woolly aphis, and also because of its vigorous growth on open soils. Its performance, following its general distribution in pear-growing localities, has demonstrated that it is considerably more resistant to pear blight than the French species and that it grows well in open, well-drained soil, but that it produces unsatisfactory trees when planted on heavy, wet, or shallow soil (figs. 12 and 13). It is blamed in California for the disease known as " black end ", which has been so disastrous in many orchards. This disease manifests itself in a deforming and blackening of the apex of the fruit, thereby rendering it unsalable. It has appeared almost exclusively on trees with Japanese roots. On soils that are not satisfactory for good tree growth, the loss from black end is often more pronounced than on open, fertile soils where the trees grow well. While the black-end trouble has caused much loss in many sections in California, it is only occasionally encountered in the fruit orchards of Washington and Oregon. In these northern districts, orchards on the Japanese roots have generally proved productive and satisfactory, though the unfortunate experience with this stock in many sections of California has caused its use to be almost completely abandoned.

In the hope of improving the growth of unsatisfactory trees and of correcting the condition that results in black-end fruit, a number of growers have inarched their trees that are on Japanese roots with French seedlings, but thus far the results of their work have not been sufficiently beneficial to warrant its commercial recommendation.

Other oriental pear stocks, notably *Pyrus calleryana* and *P. ussuriensis*, have been used in a number of orchards, and the seedlings of the former are considered worthy of extended trial by some orchardists and experimenters. The suitability of *P. calleryana* for cold regions is questionable. as there is some evidence that it is more subject to winter injury than is the French root. The planting of *P. ussuriensis* has been discontinued because it did not prove immune to blight and because of the prevalence of the black-end disease on fruit produced by trees propagated on it.

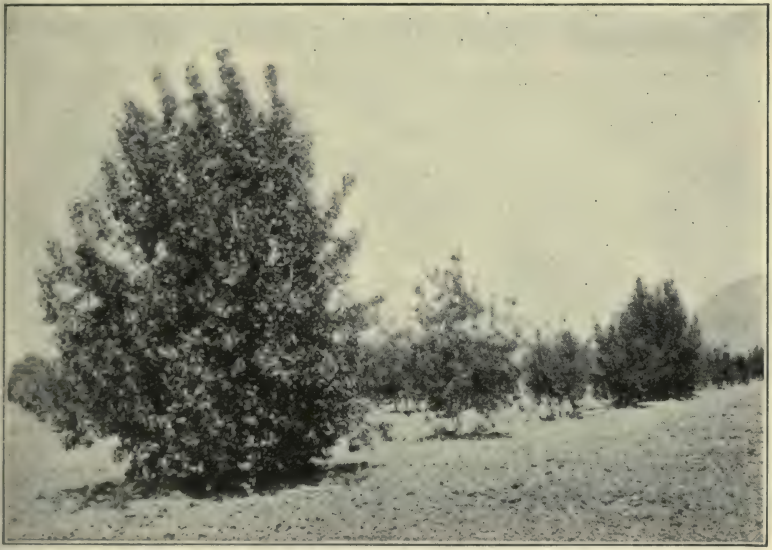

FIGURE 12.—A Bartlett pear orchard on very heavy adobe soil. The two large trees are on French roots and the others on Japanese roots. All trees are the same age. (See fig. 13.) (Kelseyville, Calif., photographed in June.)

Where the soil is shallow but otherwise adapted to pear culture or where close planting or early fruiting is desired, the quince stock is used, as it has a somewhat dwarfing effect on the top. The principal acreage planted on this stock is found in the San Francisco Bay district. As the trees on this stock come to fruiting early and more trees may be planted per acre than if standard stocks were used, heavier yields per acre may be realized for a number of years after the orchard is planted. The semidwarfing of the tree, causing early fruiting, is a decided advantage if the pear is to be used as an intercrop with other fruits.

Extensive projects for developing a satisfactory pear stock that is resistant to blight, as well as extensive searchings of the present material for one, have been under way for a number of years. One stock that has been found promising is a variety of French pear known as "Old Home." It is hoped that this variety, which is very resistant to blight, may produce blight-resistant seedlings also and therefore furnish a satisfactory stock.

ORCHARD CULTURE AND COVER CROPS

In the northern districts, including particularly Wenatchee and Yakima, Wash., and Hood River, Oreg., where an abundance of water for irrigation is available, pear orchards are largely maintained in a permanent cover crop or sod. Alfalfa is most widely used for this purpose, although there is increasing interest in sweetclover. Where such a system of culture is used, the area between the trees is seeded to the cover crop, preferably before the trees reach full bearing age. The crop is allowed to grow throughout the season, matting down to form a dense soil cover during the late summer. The usual practice is to disk such orchards in the spring, working the ground thoroughly to incorporate the vegetation from the cover crop in the soil. Irrigation in these districts is almost entirely of the furrow method. After the spring disking, furrows are opened for the summer irrigation. The disking also holds the growth of the alfalfa in check during the period in the spring when the trees bloom and when growth of the trees is most rapid. Thus the competition between the cover crop and the tree is avoided during the critical period. Following the disking, however, the alfalfa soon begins to grow, and a heavy soil cover is secured by midsummer.

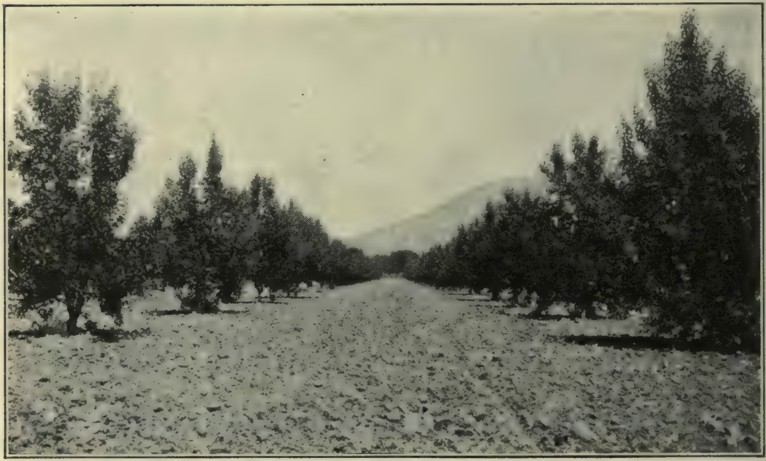

FIGURE 13.—Seven-year-old Bartlett trees on Japanese stock. The soil here is deep and open. The orchard is not irrigated. (See fig. 12.) (Kelseyville, Calif., photographed in June.)

This system of orchard management represents the minimum cost for cultivation and provides a steady supply of organic matter for the soil. The soil is shaded and is several degrees cooler throughout the season with the cover crop than where clean cultivation is practiced. The incorporation of organic matter, the minimum cultivation used, and the penetration of the roots of the cover crop, all aid in keeping the soil in satisfactory condition to take up the water readily. The disadvantages of the system of management are that somewhat more moisture is required than under clean summer cultivation. Also, the heavy growth of vegetation tends to harbor certain insect pests. This may require occasional seasons of clean cultivation.

Sweetclover has apparently been somewhat superior to alfalfa in opening up impervious soil, probably because the crop planted is a deep-rooted biennial. The dying and decay of the roots at the end of the second season's growth tend to open up impervious subsoils to an unusual degree. The top growth of the sweetclover, however, is so vigorous and upright that it may require dragging down to facilitate other orchard operations.

In districts having less abundant water supply the use of permanent cover crops in the orchard has not become general. In the Rogue River Valley district of Oregon and in practically all districts of California clean culture throughout the summer months is practiced. There the orchards are usually plowed in the spring and the soil worked down thoroughly. Shallow cultivation is usually given to the land following each irrigation. Where irrigation is not practiced, disking or other shallow cultivation is frequently practiced throughout the spring and summer to keep down native vegetation that would rob the soil of moisture needed by the trees.

In the soils of relatively heavy texture, which are often used for pears, the time for spring plowing is particularly important, especially in nonirrigated orchards. If such soil is worked before it dries sufficiently, it will dry into hard clods and remain in poor physical condition throughout the summer. If the soil is too dry it is also difficult to pulverize it satisfactorily. If a winter and spring cover crop is growing in nonirrigated orchards it is particularly important to work down the cover crop before the soil has become too dry.

In districts where permanent cover crops are not used it is a common practice to seed annual overwinter crops in the late summer. Among those most widely used are vetch, horsebeans, native legumes, and grain. In many orchards cover crops are not seeded, but an abundance of native vegetation develops in the fall after cultivation has ceased. This native vegetation is very helpful in maintaining the organic supply in the orchards. In most parts of California growth of cover crops or of native vegetation will occur during the winter months. In the northern districts the winters are too severe to permit much growth of cover crops except in the fall and early spring.

FERTILIZATION

In most districts of the Pacific coast, pears, in common with most other orchard fruits, give the greatest response to nitrogenous fertilizers. In practically all of the districts of Oregon and Washington, and in some sections of California, annual applications of fertilizers high in nitrogen stimulate the growth of the trees and improve production. On some of the deep, fertile, alluvial soils, particularly where the orchards are maintained under summer cultivation, little response from fertilizers has been obtained. Where fertilizers have proved of value, those high in nitrogen have generally been most satisfactory. Annual moderate applications, usually made in the late fall, have proved very satisfactory.

POLLINATION

The setting of fruit by all important pear varieties is aided by cross-pollination under some if not all conditions in the Pacific States. In some localities, especially in the Sacramento Valley district and near Clearlake, Calif., good crops of fruits are harvested in large orchards of the Bartlett variety where no provision is made for cross-pollination. However, many growers believe that heavier crops could be obtained some years if pollination were provided. That cross-pollination is advantageous to setting fruit of practically all varieties is now generally conceded. Provision for cross-pollination should be made, notwithstanding the fact that such varieties as Bartlett, Anjou, and others may, under favorable conditions, set fair crops when planted alone.

In providing means for cross-pollination, the interplanting of commercial varieties in alternate rows is often practiced. If a greater number of trees of one variety than of the other is desired, 2 or 3 rows of one may be planted to each row of the pollinizer. If the variety considered to be the best pollinizer is planted solely or chiefly for its benefit to the other variety, single trees may be planted at intervals throughout the orchard. One tree is considered sufficient to pollinize eight others if bees are provided to carry the pollen. The best distribution of these trees is made by planting a pollinizer in every third tree space of every third row. Another method for providing fertilization for self-sterile blossoms is by top-grafting a branch of the tree with scions from a pollinizer. This method is practiced when a solid block of one variety has been planted and the grower does not wish to remove trees to make room for planting others for pollinizers. It is obviously less desirable than interplanting, as the fruit of the individual branch will need to be harvested separately and may need other special handling.

Recent experimental evidence reported in California Agricultural Experiment Station Bulletin 373, Pear Pollination, and Oregon Agricultural Experiment Station Bulletin 239, Pollination Study of the Anjou Pear in Hood River Valley, indicate that varieties should be interplanted to provide a means of cross-pollination. From the results obtained in California it appears that the Bartlett may be successfully used as a pollinizer for most of the other important varieties, including Anjou, Bosc, Comice, Hardy, Howell, Easter Beurre, and Winter Nelis; that in the Sierra Nevada foothills Bartlett is almost entirely self-sterile, and that Winter Nelis is a good pollinizer for Bartlett. The tests made in the Hood River Valley demonstrated the desirability of cross-pollination for Anjou under those conditions. Bartlett, Easter Beurre, and White Doyenne were found to be effective pollinizers for Anjou. The bulletins cited present information on pollination that will be of value to pear growers.

PRUNING

Pruning is recognized as an important cultural operation in the production of regular crops of large-sized pears typical of the variety in shape and quality, as well as in the production of most other cultivated fruits. It is also one of the most difficult problems confronting the grower. The influence of the growth condition and the differences in characteristics of growth and production among varieties may all influence the type of pruning in a given orchard. A careful study of varietal characteristics and the influences of local conditions and treatments on them is necessary in evolving the best pruning system.

PRUNING THE YOUNG TREE

In the new orchard the problem of shaping the tree and protecting the trunk and branches from the sun is encountered. It is desirable to secure the best possible distribution of branches along the main trunk. If the nursery tree being planted is an unbranched whip, this can be done by cutting off the tree at the height desired for the topmost main branch, usually 40 to 48 inches. After the buds have started to grow in the spring, those for the main branches can be selected and the remainder rubbed off. In this way the branches can be spaced 8 to 12 inches apart along the trunk and well distributed around it. Such a distribution will make the strongest possible tree (fig. 14).

If the tree is headed at the time of planting and left without further attention until the following winter, there is a tendency for the branches to be bunched near the point of heading, with weaker crotches and greater danger from blight infection in the crotches. A distribution of branches gives a stronger tree, reduces the danger of sunburn injury (fig. 15), and reduces the danger to the tree as a whole from blight.

Following the first season and up until bearing age, the pruning that the tree should receive will vary somewhat with its growth. The less pruning, the more quickly the tree will come into bearing. Consequently, once the main branches are selected, a minimum amount of pruning should be given until the tree is in bearing. Usually a light thinning out of branches will suffice. If the growth is very strong, heading back the branches lightly for a year or two will give a more compact tree that will stand more stiffly in the wind. Heading back from the second year until the trees are in heavy bearing should generally be avoided. Three to five main scaffold branches are usually sufficient to build a good tree. With varieties susceptible to blight and where it is likely to be serious, it is advisable to leave more framework and secondary branches, as infection from this disease may make it necessary to remove some of them.

As the trees approach bearing age, corrective pruning may be necessary to secure a satisfactory fruiting condition. Most young trees make an upright growth and do not branch freely. Admitting light to the center of the tree, which is sometimes accomplished by spreading the tree by mechanical means, encourages the formation of fruit buds. An effective means of spreading the trees mechanically for early production which has been practiced in a few orchards is to bend down and tie the branches either to the trunk or to stakes driven into the ground (fig. 16). The branch that is tied down will develop numerous twigs and spurs and generally will become fruitful. This method of inducing early fruiting has been rather successful. Placing spreaders between the branches to hold them apart and thinning out some of the branches if they are close together will also be helpful in inducing fruitfulness. Once the tree is in moderately heavy production, the weight of the fruit is usually sufficient to keep it satisfactorily spread.

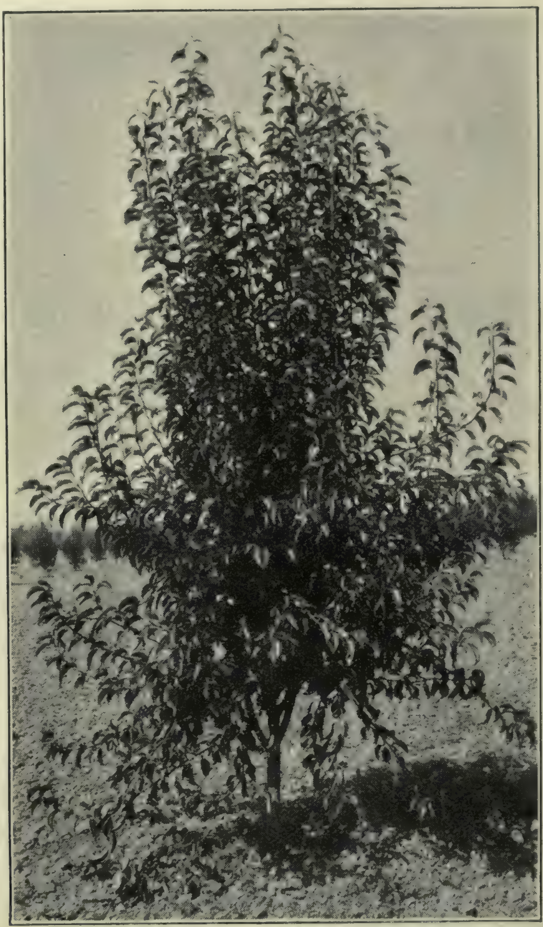

FIGURE 14.—Three-year-old Bartlett tree on which drooping branches have been left to shelter the trunk from the sun. (Kelseyville, Calif., photographed in August.)

PRUNING THE BEARING TREE

In the young tree the basic principle in pruning should be to build a suitable framework with the least possible amount of cutting and to handle the tree so as to get maximum size and production at an early age. After the tree has come into full bearing, however, different factors prevail. The purpose of pruning the bearing tree

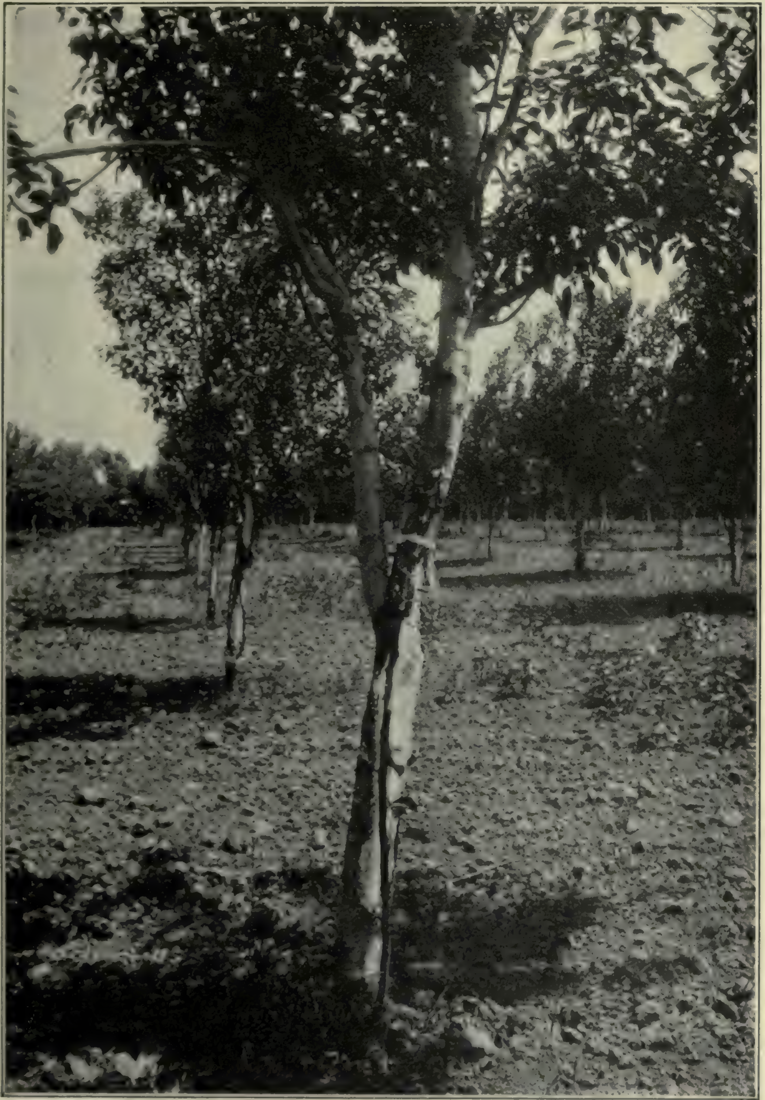

FIGURE 15.—High-headed Bartlett pear tree injured by sunburning and sun scalding following freezing weather. Sun-scald injuries on this tree have been bridge-grafted. (Vancouver, Wash., photographed in August.)

is to maintain the fruiting wood in vigorous condition in order that the trees may produce regular crops of fruit of good size and quality. In order to secure regular heavy production of fruit of good size and quality it is necessary that the fruiting spurs be maintained in vigorous growth. Pruning tends to reduce the number of fruiting points, but stimulates more vigorous growth in those that remain. In general, the minimum amount of pruning that will maintain the spurs and fruiting wood in vigorous growing condition will give the most satisfactory results. Consequently, the pruning practices for the bearing tree should be closely correlated with soil-management practices, including irrigation, fertilization, and cultivation, and with the thinning of the fruit crop.

Pear varieties may be classified into two groups, according to their bearing and growth habits. In one of these groups there is a strong tendency to develop and retain spurs throughout the tree. These varieties tend to produce little new growth except at the terminals of the branches and near points of pruning. Hardy and Lawson are samples of varieties that produce great numbers of spurs but tend to produce little new wood along the older branches. Other varieties having this tendency, though to a less-pronounced degree, include Bosc, Clairgeau, Koonce, Flemish Beauty, and, to a still less extent, Anjou and Comice.

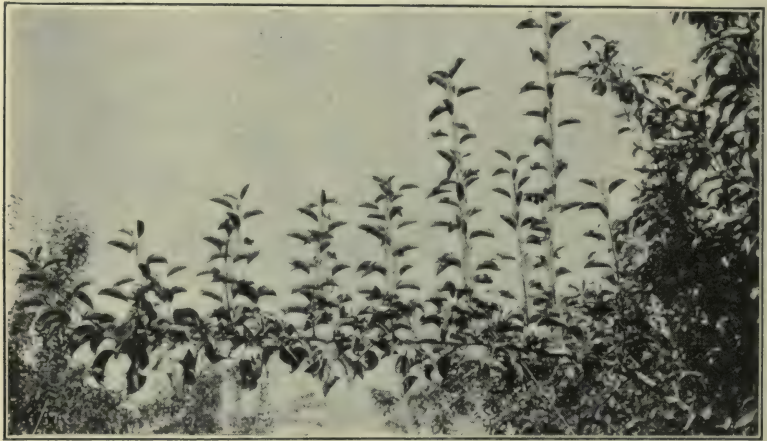

FIGURE 16.—This 2-year-old Bartlett branch was tied down to this position in winter. The new growth is typical of that on branches so treated. (Photographed in September.)

Another group of varieties tends to produce twigs and vigorous shoots not only from the terminals of the branches but along the sides of the branches as well, if conditions are favorable for wood growth. Development of spurs in these varieties is much less marked. Bartlett and Winter Nelis are outstanding examples of varieties having this growth habit; P. Barry, Glout Morceau, Forelle, and Easter Beurre would also be considered in this class. All varieties of rather low vegetative vigor tend to develop large numbers of spurs rather than to throw out the longer type of vegetative growth.

Varieties having a pronounced tendency to form spurs generally will require rather heavy and detailed pruning to maintain the spurs in a vigorous fruitful condition. The heading back of branches and new shoots to maintain the vigor of the fruiting branches and to induce growth of new branches, also the thinning out of old fruiting branches and spurs in order to maintain vigor on those that are left, are essential in such varieties.

With the varieties which have a greater tendency to form shoot growth it is generally necessary that the shoots be thinned, in order to keep the trees sufficiently opened to the light and to maintain sufficient vigor in the new growth. Moderate annual pruning on practically all bearing varieties seems desirable to maintain the trees in the best fruiting condition. In general, pruning in pear trees should be detailed and distributed over the whole tree, as the greatest response in increased vigor comes in the part of the tree adjacent to the pruning cuts.

If soil-fertility and soil-management practices are such that the trees can be maintained in a fairly vigorous condition, satisfactory results can be obtained with only a limited amount of cutting. If the pruning is reduced too much, however, it is difficult to secure adequate size of fruit even with fairly heavy fruit thinning. Over-pruning, on the other hand, reduces the bearing surface and the leaf area of the trees so much that production is likely to be decreased. A balanced program of moderate annual pruning, together with good soil-management practices, will generally result in maximum production of fruit.

In all sections where pear blight is a serious menace the danger of inducing a vigorous growth that will be very susceptible to blight must be considered. Only the heading back and the thinning out necessary to enable the tree to make a moderately thrifty growth and produce fruit of the desired size should be undertaken; unnecessary cutting that will result in a heavy new growth should be avoided. In general, the wood of the pear tree is very tenacious of its vigor and will withstand abuse in pruning or endure neglect at pruning time with less permanent injury than will many other fruit trees.

FRUIT THINNING

Many varieties of pears tend to set heavy crops of fruit which the tree is unable to develop to good marketable size. This is particularly likely to occur with such varieties as Winter Nelis, Bosc, Bartlett, and occasionally with Anjou. If medium- to large-sized fruit is desired, it is necessary to thin part of the crop from such trees, in order to have a larger leaf area per fruit.

Many pear varieties, such as Bartlett, Hardy, and Bosc, tend to set the fruit in clusters, often 3 to 5 fruits setting on a single spur. If the set of fruit on the tree as a whole is excessive, these clusters should be reduced to one or two fruits each. On the other hand, if the set of fruit on the tree as a whole is not excessive, fruit on these clusters will reach satisfactory size and quality without thinning.

It is impossible to lay down hard and fast rules for the thinning of pears. The number of fruits a tree will carry and develop to good marketable size will vary with the vigor of the tree and with the growing conditions. Experiments indicate that, with nearly all varieties, from 30 to 40 good leaves per fruit are essential for the building of the materials that go to make the fruit. These leaves, however, need not be directly adjacent to the fruit. With extremely heavy sets of fruit, thinning to reduce the amount of fruit in proportion to the leaf system is essential if fruit of best size and quality is to be obtained.

Under present standards larger sized fruit is required for canning than for fresh market purposes. If the crop is intended primarily for cannery use it is particularly esential that fruit of good size be secured.

PEAR HANDLING AND STORAGE

Since pears, both for fresh shipment and for canning, are harvested prior to becoming tree-ripe, the question of the state of maturity at which they are picked is very important. If they are harvested too early, the quality is poor; if they are allowed to become too mature on the tree the storage life is shortened, and many varieties tend to break down at the core while still sound at the surface. Numerous investigations to determine the proper picking maturity of pears and the best methods of handling following harvest have been conducted. United States Department of Agriculture Technical Bulletins 140, Investigations on the Handling of Bartlett Pears from Pacific Coast Districts, and 290, Investigations on Harvesting and Handling Fall and Winter Pears; California Agricultural Experiment Station Bulletin 470, Maturity Standards for Harvesting Bartlett Pears for Eastern Shipment; Oregon Agricultural Experiment Station Bulletins 228, Investigations on the Harvesting and Handling of Bosc Pears from the Rogue River Valley; and 254, Further Investigations on the Harvesting, Storing, and Ripening of Pears from Rogue River Valley, discuss in detail the problems of pear harvesting and handling.[2]

INSECTS AND DISEASES

Several insect pests and diseases cause serious losses in commercial pear orchards in the Pacific Coast States. Fire blight, scab, and black end are the most serious diseases, while the principal destructive insects are the pear-leaf blister mite, codling moth, pear thrips, and red spiders. Familiarity with the performance of the insect or disease in the locality where the orchard is situated is necessary, as success depends upon the precision used in choosing the time for the application of control measures, as well as upon the thoroughness of the application of the remedy. The State experiment station or county agricultural agents should be consulted for specific instructions as to control practices in the various districts.

INSECTS

Pear leaf blister mite.[3]—Injury to both leaf and fruit is caused by this insect but good control may be expected to follow a thorough application of lime-sulphur when the buds are beginning to swell in the spring.

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[2] The two U. S. Department of Agriculture bulletins may be purchased from the Superintendent of Documents, Washington, D. C., for 10 and 15 cents, respectively. Persons desiring copies of the other publications should communicate with the State experiment station publishing them.

[3] *Eriophyes pyri* Pgst.

Codling moth.[4]—The codling moth is abundant in all pear-growing localities of the Pacific Coast States and causes heavy loss to almost all pear growers. In addition to the loss of fruit that is made unsalable by the moth is the expense of spraying for its control and of removing the spray residue from the fruit. There are two or more distinct broods of codling moth in the Pacific Coast States, but these emerge at different times in different localities, depending upon seasonal variation.

Pear thrips.[5]—This very destructive insect injures the opening blossom clusters and blossoms. It may be controlled by spraying as the buds are opening with an oil emulsion or a miscible oil at a strength of 2 gallons in 100 gallons of water, to which should be added 1 pint of nicotine sulphate (40 percent nicotine). The nicotine may also be used with lime-sulphur if that material is used for scab control, in which case the oil should be omitted.

Red spiders.[6]—Several species of red spiders or mites often cause much injury to pear leaves. They are most numerous in orchards in dry, hot localities where irrigation is not practiced or where it has been neglected and the soil allowed to become dry. The eggs of certain species of these mites may be killed with a dormant-strength oil emulsion or lime-sulphur applied late in the winter when the buds begin to swell, and all of the species may be controlled by the application of sulphur materials or summer oil sprays when the first mites appear in the spring. Prompt and thorough treatment is important.

DISEASES

Blight.—Blight, caused by a bacterium, is by far the most destructive disease that attacks pears. It is prevalent in most of the important pear-growing sections of the Pacific Coast States.

The disease usually appears first as a blossom blight, later spreading to shoots. Blighted blossoms and the leaves of blighted shoots turn brown, then black, and remain attached to the tree. From blighted blossoms and shoots the disease may enter the trunk and main limbs, causing cankers in which the bacterium may live over winter and act as a source of infection for the next season. Control consists of the removal of all infected spurs and branches as soon as they appear and of the removal of affected areas on the large branches, crotches, trunks, and roots during the dormant season. In all this work cutting tools should be disinfected so as to prevent transmitting the disease. In localities where blight is a menace, weekly visits to every tree should be made during the spring and summer by some one experienced in blight control. Helpful preventive measures consist in removing all root suckers and succulent water sprouts on the body of the tree in fall or winter and employing cultural and pruning practices that oppose vigorous wood-growth. State experiment stations and county agricultural agents should be consulted from time to time in regard to the most modern methods of control of blight, as many experimenters are working on the subject.

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[4] *Carpocapsa pomonella* L.

[5] *Taeniothrips inconsequens* Uzel.

[6] *Tetranychus telarius* L., *Paratetranychus pilosus* C. and F., and ***Bryobia praetiosa*** Koch.

Scab.—Scab is a fungous disease that appears as dark, moldy patches on both fruit and leaves. It often causes heavy reduction in yield and serious defoliation in districts having considerable spring rainfall. Spraying, (1) when the winter buds first show individual flower buds, (2) just before the first flowers open, (3) directly after petal fall, (4) 3 weeks later, is recommended for controlling scab. Bordeaux mixture or lime-sulphur (summer strength) are recommended generally, but on certain varieties that are severely injured by these sprays, one of the milder sulphur sprays should be used. For specific directions on spraying, experiment stations of the State, or of the United States Department of Agriculture, should be consulted. Removal or plowing under of the fallen leaves in winter or early spring is an aid in control.

Black end.—Black end is a term applied to fruits which become hard, rounded, or often black over the blossom end as they approach maturity. The trouble occurs almost exclusively on trees propagated on oriental stock. No satisfactory control measure has been found, but the trouble may be avoided by using seedlings of the French pear for rootstocks.

PRINCIPAL PEAR VARIETIES IN THE PACIFIC COAST STATES

ANJOU

The Anjou is a pear of French origin and has been grown in the Pacific Coast States over a long period, though most large plantings have been made during the past 20 years. The Anjou is found in limited quantities in some of the pear-growing districts of California, but has become an important variety in Washington and Oregon. It is prized because it keeps well in storage and may be marketed over a long period. The fruit is of good size, high in dessert quality, and very attractive. The tree is vigorous and reaches large size (figs. 10 and 11), and is the most resistant to blight of any of the large, high-quality varieties. It is considered a good and consistent bearer after it reaches bearing age, but is very slow in coming into production. The Anjou is harvested about midseason among the fall and winter varieties, but if carefully handled may be held in cold storage until April.

A peculiarity of the Anjou is that blight infection in trunk and crotches is much more common in comparison with twig and branch infection in it than in the other varieties. Although but little if any blight may be found in the shoots on small branches, the search for infection in the crotches, which if left untreated would soon do serious damage, must not be neglected.

BARTLETT

In all principal pear-growing districts of the Pacific States, with the exception of the Rogue River Valley, the acreage of Bartlett is considerably greater than that of all other varieties combined, and in most localities it is still a favorite for planting.

The trees are adapted to a wide geographical range and to a great diversity of soil and climatic conditions. It is prolific, bears regularly, and endures neglect, abuse, and uncongenial surroundings surprisingly well. These tree characters, combined with the quality of the fruit and the uses in which it may be employed, give the Bartlett the rank of a truly remarkable fruit. Its susceptibility to blight, however, causes it to be condemned by many growers even if they are forced by its good qualities to continue to plant it. The high standard of the variety is such that a Bartlett tree that has been killed by blight is usually replaced by another Bartlett, and orchard extensions are usually made by planting trees of this same variety. As with other varieties, sufficient coolness in summer will shield it from blight, but high temperatures are desirable to obtain fruit of the highest quality.

Where well grown, the Bartlett is generally considered the standard of excellence by which other pears for fresh shipment are measured. It is the only variety in the West to be used for all purposes. In flavor and texture it is unsurpassed among the large-fruited, commercially grown pears in the Pacific States. It is the first of the important commercial varieties to ripen, the picking season ranging from early July in the valleys of central California to late August at the high elevations in California and in the northern districts.

The Bartlett fruit may be held successfully up to 2 months in cold storage. Fruit of this variety is normally off the fresh markets by the middle of October. The Bartlett reaches its highest perfection, both in dessert quality and in storage and handling quality, when grown under fairly hot summer conditions. In the coastal districts of all the Pacific States, where summers are very cool, the fruit does not keep as well following harvest and usually is less rich in flavor than in the hotter interior districts. Fruit from these coastal districts is usually canned or consumed locally, as the carrying quality is not sufficiently good to allow shipment to distant markets.

BOSC

Like the Anjou, the Bosc has attained most of its popularity on the Pacific slope during late years and in the pear-growing districts of Washington and Oregon. In these districts it is now one of the most-favored varieties for planting. The largest acreage of this variety is to be found in the Rogue River Valley of Oregon, where the fruit attains a high degree of perfection. Small plantings in the Santa Clara Valley of California indicate that it is fairly well adapted to conditions there, although it is rarely found elsewhere in California.

The fruit grows to good size, and the yellow skin, which is almost covered with a brown russet, is particularly attractive. It is considered a fall and early winter fruit, reaching prime market condition in October and November. It ripens a little after the Bartlett and before the Anjou. The tree comes to bearing fairly early and bears regular and heavy crops.

The Bosc tree, particularly while young, is difficult for the pruner to manage. The branches produce vigorous new shoots from their terminals; these remain rather slender for a considerable time and branch but little, so that the tree remains open and often becomes ungainly and willowy by the spreading of the slender branches.

Special attention is required to maintain a tree of desirable shape. Trees of this variety are attacked by blight about as seriously as trees of any of the other principal commercial varieties and are somewhat less tolerant of poor soil drainage than those of many varieties.

CLAIRGEAU

The Clairgeau is being planted but little at present, as the fruit, while large and attractive, is coarse in texture and second rate in flavor when compared with the best varieties. It has a storage season of only 2 to 3 months. Clairgeau trees are found in a number of older orchards in the San Francisco Bay district and in other localities in the cooler seacoast valleys of California. The tree grows well, and so far as pruning is concerned is one of the easiest trees to manage. The old branches have sufficient vegetative vigor to maintain thrifty and productive spurs, and these make considerable annual growth and branch freely for many years. The new-shoot growth is largely from the terminals of the branches. The growth of the spurs makes rather compact branches, but the sparse branching at the terminals of the limbs permits an abundance of light to enter; therefore, by heading back the new terminal shoots it is easy to keep the tree sufficiently open and of the desired shape.

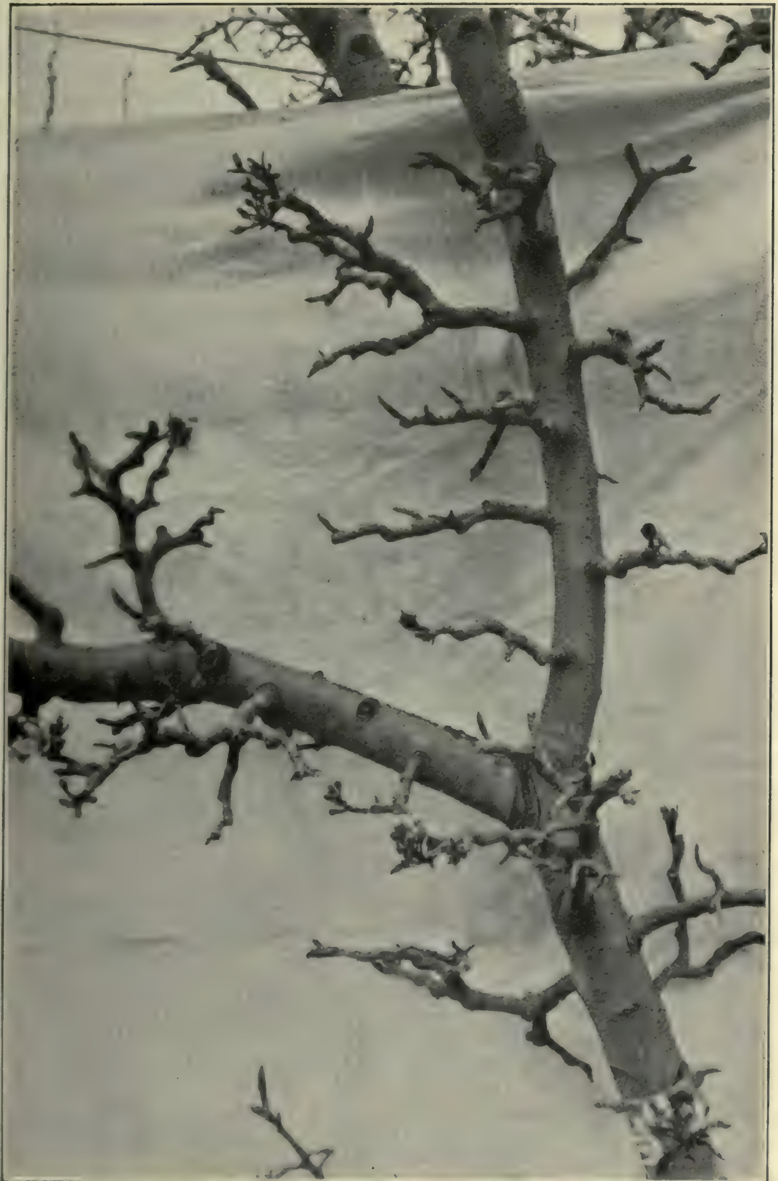
HARDY

The Hardy is known by the two uses to which the tree is put—producing fruit and grafting on quince root as an intermediate stock on which to graft other varieties. It is used for both of these purposes in California, although the use of quince stock is limited. This variety is not very generally planted, but near San Francisco Bay and in the cooler portion of the Santa Clara and San Juan Valleys it has been a popular variety for some time. The fruit is of good size and of attractive shape, keeps and handles fairly well in storage, and attains an attractive flavor. It ripens soon after the Bartlett and before the Bosc and the Anjou. It is a favorite for export on account of its relative earliness, coupled with a carrying quality much superior to that of the Bartlett.

The Hardy tree grows well, is a regular and heavy bearer, and appears to be more resistant to blight than the Bartlett. It is rather easily handled by the pruner, for, although it is a strong grower, it is not inclined to branch too freely, so that the tree remains open. Much of the new growth takes place at the terminals of fruiting branches or where branches are headed back or removed. Numerous large fruiting spurs instead of shoots develop along the fruiting branches and remain vigorous and productive for many years (fig. 17).

COMICE

In the Santa Clara Valley of California and the Rogue River district of southern Oregon the Comice is grown to some extent.



IGURE 17.—Some 12-year-old spurs on secondary branches of a Hardy pear tree. This tree is on quince root and is growing in deep, fertile, irrigated soil. It bears good and regular crops. (Santa Clara, Calif., photographed in April.)

although it is one of the minor varieties in both acreage and production. It is usually found in the older plantings but has been planted little during recent years because of its failure to bear heavy crops consistently. The Comice tree is open and rather easily managed by the pruner but is not as consistent in bearing habits as many other varieties. The fruit is large, light greenish yellow in color, and of excellent dessert quality. In flavor it is among the very best of the pears. It keeps well if handled carefully, but is one of the most easily bruised among the commercial varieties. The skin is tender and easily punctured, and even light bruises at picking time will result in darkened areas on the fruit. It is also readily injured by the rubbing of leaves and branches.

EASTER BEURRE

Among the pear varieties grown on the Pacific slope, the Easter Beurre is one of the latest to ripen. The trees are heavy producers, and the fruit keeps and handles exceedingly well, holding until May in cold storage if carefully handled. For these reasons the variety is retained. The coarseness of the fruit and the rather unattractive green color, which is often patched with russet, prevent much extension of its planting. The fruit is large and prized for baking. The tree is more resistant to blight than most varieties and grows to large size. Easter Beurre is sometimes grown as a pollinizer for Winter Nelis.

FORELLE

The Forelle is a late fall variety which is grown only sparingly because of its susceptibility to blight; it is probably less resistant than any other of the commonly grown varieties. Limited plantings in the rather cool Santa Clara Valley of California, where blight is not a serious menace, have proved satisfactory. Although the trees do not grow to large size, they bear regularly and well. The speckled fruit with its greenish yellow skin and brilliant red cheek is very attractive. It is juicy and has a pleasing flavor.

GLOUT MORCEAU

In the San Francisco Bay district and other coastal valleys of central California the Glout Morceau is still grown to some extent, although it is seldom planted at present. It is not considered as profitable as most other late-ripening varieties. Its cold-storage season extends until early spring. The tree is a good grower. The greenish-yellow fruit, although smooth, is not particularly attractive, but it is juicy, of a smooth tender texture, and of good flavor. Deformed fruits are common with this variety; in some years large quantities of fruit are thrown out as culls from this cause.

WILDER EARLY

Fruit of the Wilder Early is ready for shipment from 2 weeks to a month before the Bartlett and is one of the best of the early pears. The fruit is small, but the red cheek and yellow skin make it attractive. The tree grows rather slowly and remains open, as there is little branching. There is a decided tendency to alternate bearing, the trees producing excessive crops one year and remaining almost fruitless the following year. Usually not all trees in the orchard produce their crops the same year, however. On bearing spurs of the Wilder Early the leaves are usually small, whereas those on trees that are not bearing are of good size and shape.

Wilder Early is not much grown, but may be found in numerous localities in the warmer pear-growing valleys of California and occasionally in the Sierra Nevada foothills.

WINTER NELIS

The Winter Nelis is the most widely distributed variety of winter pear on the Pacific coast, although the acreage devoted to it is not increasing nearly as fast as that of the more popular early winter and winter varieties, Bosc and Anjou. It has been more favored in the Santa Clara Valley of California, the Rogue River Valley of Oregon, and the Yakima Valley of Washington than elsewhere. Only a very limited acreage of it is found in other districts, largely because of the failure of the fruit to reach the desired size.

The fruit is attractive with its greenish-yellow color and large areas of heavy, dark-brown russet that sometimes entirely cover the fruit. The flesh is tender and juicy, and in flavor it is among the very best of the pears. It is also one of the best pears for storage purposes. When placed in cold storage as soon as picked, it will keep until well into the following spring.

Young Winter Nelis trees present a difficult problem to the pruner, both in the nursery and the orchard. The young shoots make a thrifty growth but lack the tendency to form symmetrical trees, become tangled or drooping, and are difficult to manage. The tree attains a large size, but it needs a better soil than some varieties to produce fruit of good marketable size. It is prolific, and unless the fruit is thinned it is likely to be small. Desirable sizes of fruit are usually obtained from trees growing in deep fertile soil if given sufficient irrigation and pruned rather heavily (fig. 18). As new shoots are produced in considerable number and are rather slender, much thinning out is needed at pruning time, and also some heading back of the remaining shoots is often required to maintain the vegetative vigor necessary for the production of large fruit. It is claimed that light crops of this variety have sometimes been due to faulty pollination. The Easter Beurre is considered a good pollinizer for it and is sometimes grown for that purpose. In its resistance to blight, this tree is somewhat superior to the Bartlett.

THE FUTURE OF PEAR GROWING IN THE PACIFIC COAST STATES

The high quality of the fruit produced, coupled with the heavy and dependable production, assures the permanency of the pear industry in the Pacific coast region. The pear acreage increased rapidly between 1920 and 1930, however, and some difficulty has been experienced in marketing the greatly increased production during heavy crop years. Much of the recent planting is on land well adapted for the purpose, so the present annual production probably will be maintained or increased for a good many years to come. Pear orchards, where well located and well cared for, are long-lived; many orchards more than 50 years of age are still producing large crops of high-quality fruit.

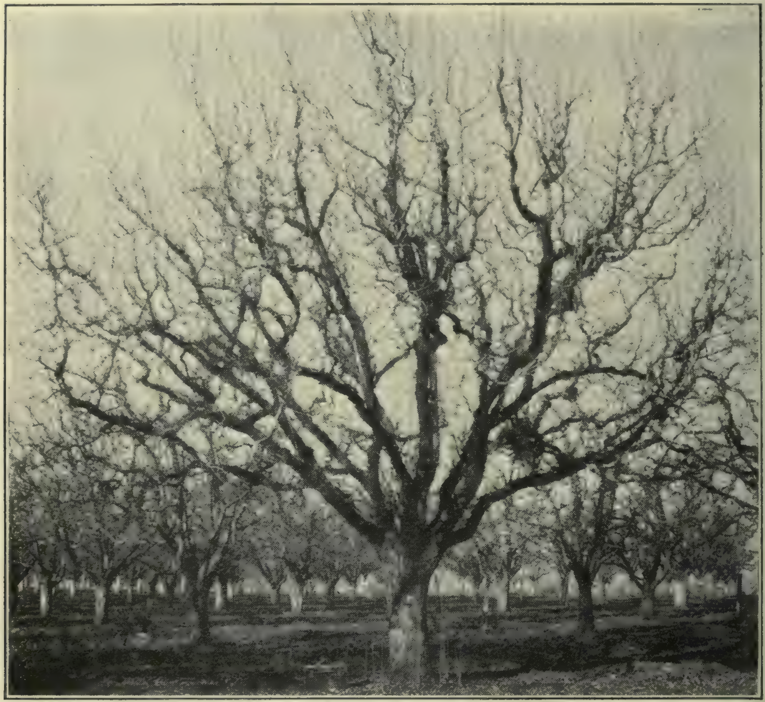


FIGURE 18.—Winter Nelis pear tree growing in deep, fertile, irrigated soil. The photograph was taken before the annual winter pruning. (Santa Clara, Calif., December.)

Considering these factors, extensive increase in the present pear acreage seems undesirable. It is probable that certain orchards on undesirable rootstocks or on poor soil will prove unsatisfactory and limited replacement of such acreage by new orchards may be desirable. The present production is sufficient in normal years to provide about all the fruit the market can utilize, particularly of the summer and early-fall varieties.

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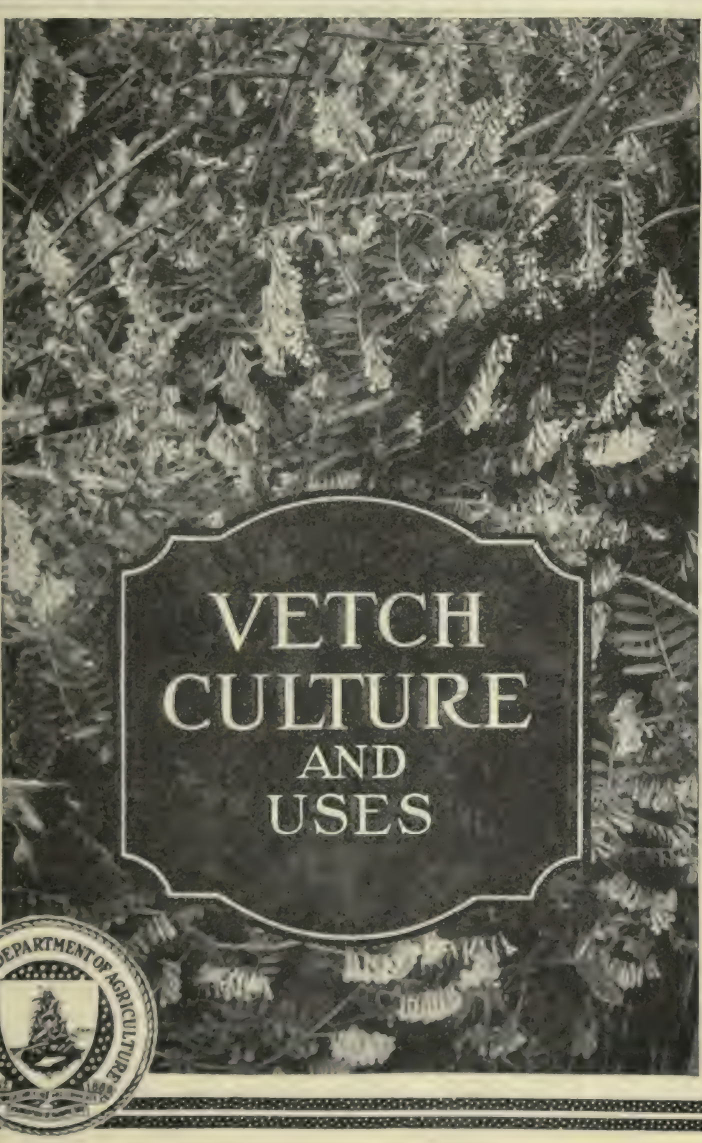

VETCH CULTURE AND USES

VETCHES, either green or as hay, make excellent feed and are also used extensively as cover and green-manure crops.

While much of the hairy vetch seed used in the United States is imported, some seed of all the commercial vetches is produced in this country, and seed of hairy vetch, common vetch, and Hungarian vetch is produced in rather large quantities.

From 30 to 60 pounds of seed per acre usually is required in seeding, depending on the variety. All vetches are fall-sown except in the extreme North.

In most of the Cotton Belt of the southeastern part of the United States, the use of inoculating cultures and fertilizers in growing vetch is essential; in the western part of the United States, inoculating and fertilizing are not so necessary. On lands that are low in fertility, however, both inoculation cultures and fertilizers can be used to advantage.

This bulletin is a revision of and supersedes Farmers' Bulletin 515, Vetches.

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VETCH CULTURE AND USES

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INTRODUCTION

PLANTS of the genus *Vicia* are commonly referred to as vetch. A large number of species are distributed throughout the Temperate Zones of both hemispheres, several of which have been recognized as of agricultural importance from very ancient times. Common vetch and hairy vetch have been used extensively in both the Old and New Worlds. One rather universally grown species of *Vicia*, *V. faba*, is seldom referred to as a vetch, but is more commonly called horsebean or broadbean. This species, grown mostly for its seed, which is used as a vegetable, is also used for green manure. Other species of *Vicia* are used largely for forage and green manure. The vetches of most importance are common vetch (*Vicia sativa*), hairy vetch (*V. villosa*), smooth vetch (*V. villosa*), purple vetch (*V. atropurpurea*), narrowleaf vetch (*V. angustifolia*), woollypod vetch (*V. dasycarpa*), bittervetch (*V. ervilia*), monantha vetch (*V. monantha*), Hungarian vetch (*V. pannonica*), and Bard vetch (*V. calcarata*). With the exception of bittervetch, which is grown in countries bordering the Mediterranean, these species are all used in the United States.

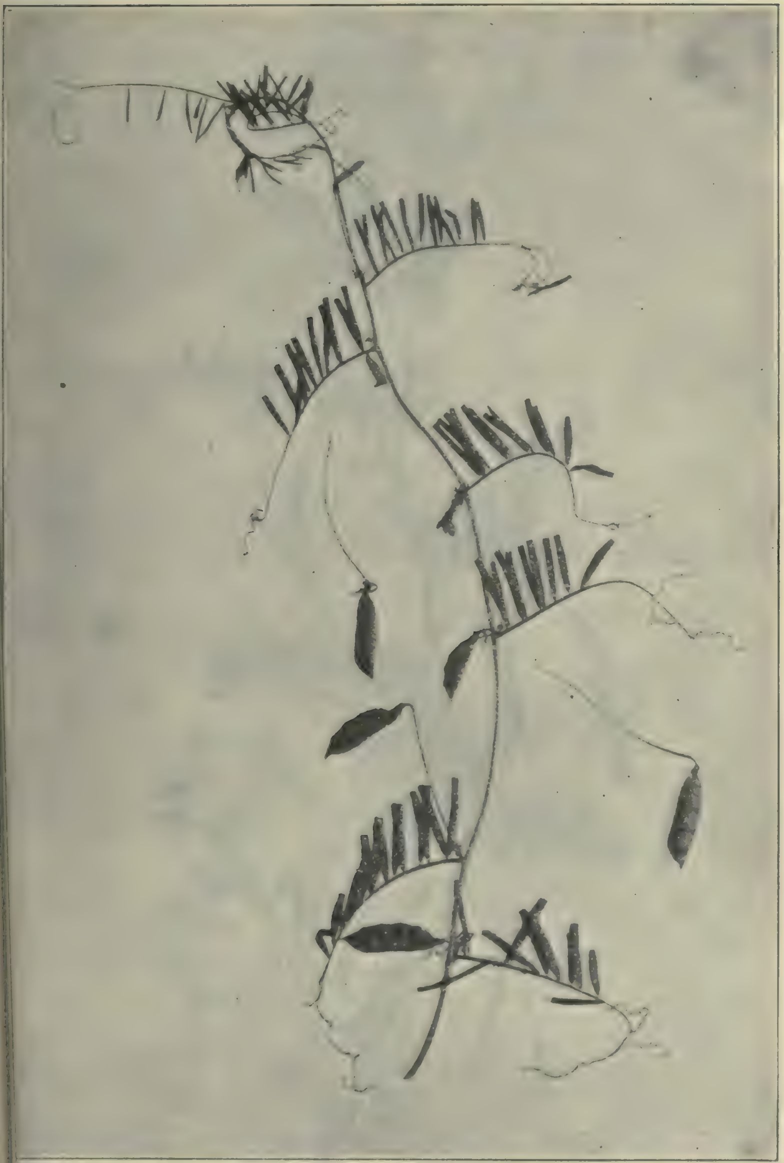
DESCRIPTION

The genus *Vicia* includes botn annual and perennial plants. Most of the common vetches are annuals, however, and hairy vetch is either annual or biennial. With few exceptions vetches are more or less viny (fig. 1). The common agricultural species are all viny or weak-stemmed, with the exception of the horsebean or broadbean, which is quite upright. The stems attain a length of from 2 to 5 or more feet, depending upon the species and conditions under which the plants are grown. In all cultivated species the leaves have many leaflets and are terminated with a tendril, excepting *Vicia ervilia* and *V. faba*, which have little or no tendril. From few to many flowers are borne in a cluster or raceme. Seed and pod characteristics vary with species, but in general the seed is more or less round or oval and the pods elongated and compressed (figs. 2, 3, and 4). The common commercial vetches can be distinguished by the following simple key and short descriptions.

FIGURE 1.—Hungarian vetch in full bloom, showing general habit of growth.

KEY TO COMMERCIAL VETCHES

- Plants decidedly hairy.
  - Flowers many in a cluster, stalked, purple.
    - Pods hairy, seed scar with white appendage---- Purple vetch.
    - Pods smooth, seed round, seed scar smooth, without appendage------------------------ Hairy vetch.
  - Flowers few (2 to 6) in a cluster, not stalked, nearly white-------------------------------------- Hungarian vetch.
- Plants smooth or nearly so.
  - Flowers stalked.
    - Flowers many in a cluster, purple.
      - Pod smooth, seed round------------------ Smooth vetch.
      - Pod finely hairy, seed oval to nearly round-- Woollypod vetch.
    - Flowers one or few in a cluster, light lavender or nearly white (except Bard vetch).
      - Leaves without tendrils------------------ Bittervetch.
      - Leaves with tendrils.
        - Seed decidedly flattened, flowers one, light lavender--------------------- Monantha vetch.
        - Seed oval or round, flowers two, purple- Bard vetch.



RE 2.—Portion of a stem of monantha vetch, showing leaves, flowers, and pods. (About one-half natural size.)

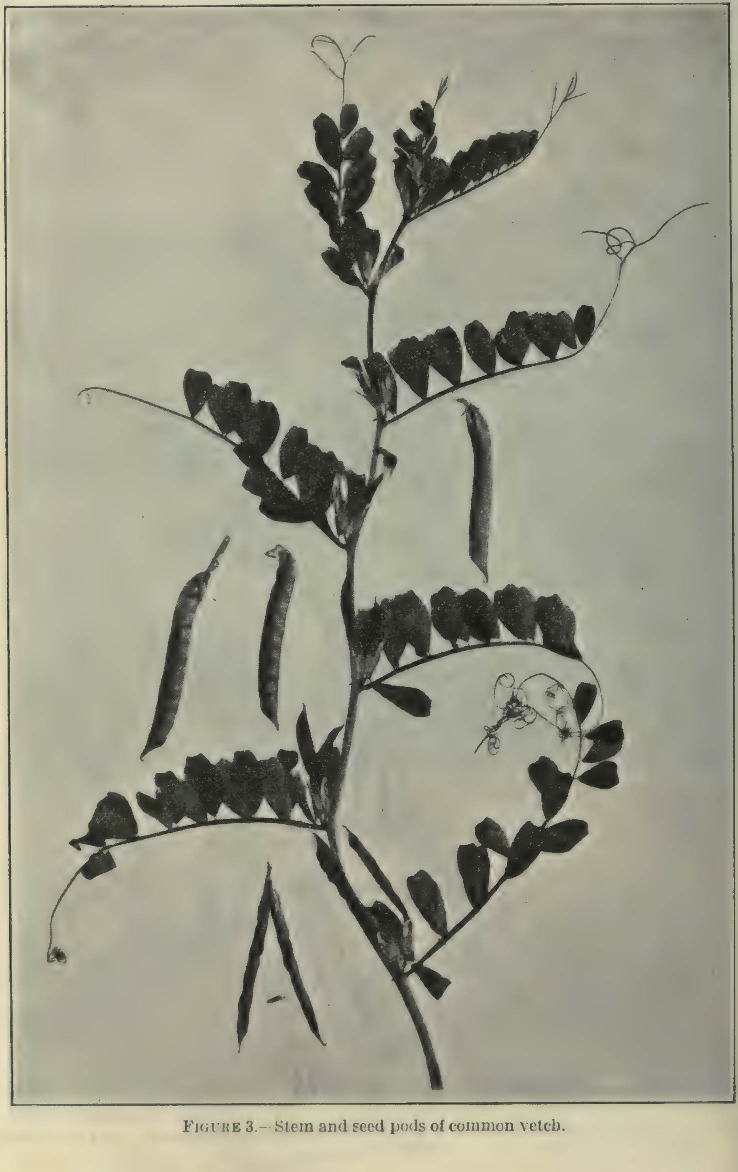


FIGURE 3.—Stem and seed pods of common vetch.

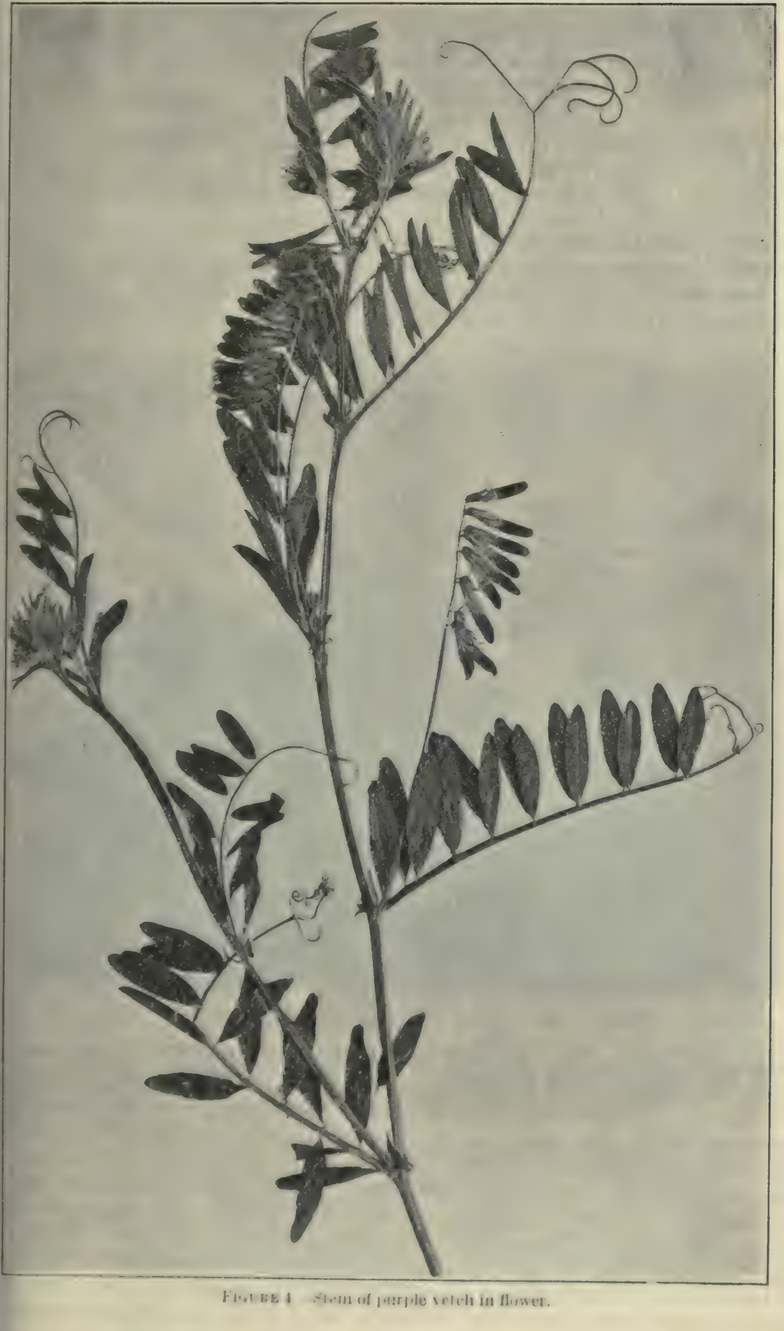


FIGURE 1.—Stem of purple vetch in flower.

Plants smooth or nearly so—Continued.	
Flowers not stalked.	
Plants upright, leaves large and very broad to nearly round; seed very large	Horsebean.
Plants viny, leaves narrow to oval and obovate, seed not large, flowers purple.	
Pods turning black, leaflets always narrow	Narrowleaf vetch.
Pods not turning black, leaflets seldom narrow	Common vetch.

CLOSE RESEMBLANCE IN VETCHES

While some of the vetches have very distinctive characteristics, others are very much alike and sometimes are almost indistinguishable. Vetches representing different species will seldom be confused. Woollypod vetch (fig. 5) and smooth vetch, however, are hard to distinguish except by the pod and seed characteristics, and purple vetch is difficult to tell from hairy vetch until the flowers and pods are developed. Narrowleaf vetch is similar to some narrow-leaf forms of common vetch and can only be told by its black pods and slightly different seed characteristics. Hairy vetch is distinguished from smooth vetch by the heavy pubescence or hairiness of the stems and leaves in the former and the small amount or lack of hairiness in the latter. The seed of these two varieties is indistinguishable. Woollypod vetch has slightly smaller flowers than hairy or smooth vetch, but its leaves and stems are like smooth vetch. Its seed, however, can be distinguished from these two varieties, since it is somewhat oval and has a groove through the middle of the seed scar. Only two varieties

FIGURE 5.—Woollypod vetch in an experimental planting, showing general habit of growth.

of common vetch are grown in the United States, and these are distinguishable only by the seed. One goes under the name common vetch or Oregon common vetch and the other pearl vetch. The pearl vetch has salmon-colored seed, while Oregon common vetch seed usually is blackish brown or dark gray.

CLIMATIC REQUIREMENTS

The vetches require cool temperatures for their best development. In regions with mild winters, as in the Southern and Pacific States, they make their growth during the fall, winter, and early-spring months, maturing in late spring and early summer. In the North, where winters are severe and summers moderately cool, they start growth in early spring and mature in late summer or fall. Species vary with reference to winter-hardiness and the minimum temperature at which they will make growth. Hairy vetch is the most winter-hardy of the commercial vetches and is the only one that is recommended for fall planting in the North.

In regions where temperatures do not fluctuate violently or where there is protection of snow, Hungarian, woollypod, and smooth vetches will stand a temperature of 0° F. or lower. Common vetch has a great many varieties, but without protection none will stand zero weather. The variety grown in the northwestern part of the United States under the name common vetch or Oregon common vetch is one of the most winter-hardy and in general can be said to stand 10° without injury under average conditions. Bittervetch, purple, monantha, and narrowleaf vetches are all less hardy than common vetch, and with fluctuating temperatures will suffer injury at 10° to 15°. In the Gulf Coast States, except in the extreme southern part, these vetches usually are injured by average winter temperatures. A few wild species of vetch are very winter-hardy. One of these, a native of the northern part of the United States, is known as bird vetch (*V. cracca*). This is a perennial and in some places occurs in considerable abundance.

USES OF VETCH

All of the commercial vetches make good hay, silage, pasturage, and green manure, and can be used for cover crops and feeding green. The seed is used as one of the ingredients in ground poultry feed, which is frequently an outlet for surplus and waste.

The vetches make good hay either alone or in mixture with the small grains and are relished by all kinds of livestock. Common and Hungarian vetch are the species most generally used for this purpose, but hay from the others should be equally good. In river-bottom lands of the South where Johnson grass is established, narrowleaf vetch often occurs in abundance and makes up a good part of the hay from such areas.

Vetch planted with one of the small grains is often cut green and fed to cattle or other livestock. Common vetch is thus fed in western Oregon (fig. 6). Succulent late-winter and early-spring feed can be supplied in mild climates in this way with but little expense.

For pasturage the vetches alone or in mixture extend the grazing season by supplying late-fall and early-spring feed. They stand trampling and are well suited for pasturage.

Probably the greatest use of vetch is for green-manuring. In the past common and purple vetches have been used extensively for this purpose but are less used at present. Hairy vetch and smooth vetch are used for cover and green-manure crops in the Cotton Belt and make up about half of the green-manure and cover-crop acreage of that region. Monantha vetch is used for green manure and as a cover crop in the extreme South, and purple vetch is used for green manure in California. Hairy, smooth, common, Hungarian, monantha, and purple vetches are all grown for seed in limited areas of the United States.

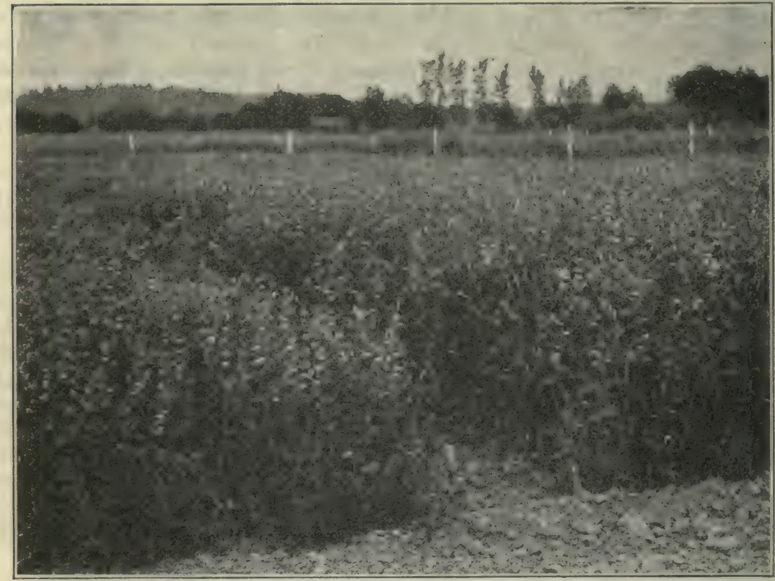


FIGURE 6.—Oregon common vetch grown alone (left) and in combination with oats (right).

CHEMICAL ANALYSES

The chemical analysis of any plant varies with its age; the protein content is high in young plants and the crude fiber low, while in old plants the protein is lower and the crude fiber higher. Plants with a high protein content are recognized as having high feeding value. The limited number of available chemical analyses of vetches indicate that the vetches are comparable in feeding value to clover, alfalfa, and other common legume crops. The protein content of hay usually ranges from 12 to 20 percent, depending upon the stage of development of the crop when cut.

SOIL AND MOISTURE REQUIREMENTS

In general vetches are not particular in regard to soil, although some do better on certain soils than others. All do well in rich loam. On poor sandy lands hairy, smooth, and monantha vetches do well, while Hungarian vetch succeeds on heavy wet soil where other kinds fail or make but little growth. A moderate moisture supply is necessary for vetches, and none are drought-resistant. Under dry-land tests hairy and purple vetches have stood up somewhat better than the others, but cannot be considered adapted to such conditions.

Vetches are more tolerant of acid soil conditions than most legume crops, and outside the lime-belt areas in the eastern part of the United States succeed without the addition of lime.

PREPARATION OF THE SEED BED

In the South most of the vetch is seeded following cotton. Under such conditions but little or no preparation of the soil is needed, as the cultivation of the cotton throughout the season makes a reasonably good seed bed. The same is true when the vetch is planted following soybeans, cowpeas, or Spanish peanuts, or any other cultivated crop. Under such conditions the seed is sown broadcast and disked in, provided the previous crop has been harvested sufficiently early.

On clay soils and where there is a heavy weed growth or the soil is firmly packed, plowing or heavy disking will be essential in order to give a good seed bed. For best results, it is desirable to have the soil reasonably well firmed, as this will insure better surface moisture conditions and consequently good seed germination.

In the Pacific Northwest disked seed beds are used when vetch follows cultivated crops or spring-seeded small grains, while plowing and subsequent preparation is practiced on fall grain stubble or uncultivated land. Usually no special soil preparation is practiced in orchards that have been clean-cultivated during the summer previous to seeding vetch for green-manure and cover-crop purposes.

TIME OF SEEDING

Latitude determines in a general way the time of seeding. In the extreme North or north of latitude 40°, from the Rocky Mountains to the Atlantic coast, all commercial vetches except hairy vetch should be sown in early spring. Hairy vetch in this region should be sown during August or early in September. On the Pacific coast west of the Cascade and Sierra Nevada Mountains, with few exceptions, vetches can be safely sown in the fall. In the colder parts purple vetch will occasionally winter-kill, but in average winters it is hardy.

In western Oregon, western Washington, and northwestern California, vetch should be seeded as early as the seasonal rains will permit. Usually this will be in the latter part of September or early October. In other parts of California, where the climate is mild and where irrigation is practiced, seedings should be made from the middle of August to the first of October. In the mild parts of Arizona, seedings should be made about the same time as in California. For green-manure crops the planting date should be early, while for hay or pasturage later seeding sometimes is equally satisfactory.

In the northern part of the Cotton Belt the best time for seeding vetch is the latter half of September and in the southern part early in October. Early seeding in the Cotton Belt is desirable, in order to get as much fall growth as possible, but where nematodes are numerous, early seedings may be seriously damaged. In general, seedings made about the first of October escape with but little nematode injury. Very late seedings, or seedings made as late as the first of December, will usually result in poor stands because of winter-killing, and but little growth will be made by the time the crop should be turned under for corn or cotton.

RATE OF SEEDING

The rate of seeding to give good stands has been reasonably well determined by experimental work. Local variations in the soil, preparation of the seed bed, and winter temperature are factors that influence the rate of seeding, but in general the range of variation in the quantity needed is not great.

In table 1 is given the quantity of seed per acre considered advisable for different vetches under the conditions designated. When a seed drill is used, a smaller quantity is required than when the seed is broadcast, and thoroughly prepared land requires less seed than land that is rough and poorly prepared. Under favorable conditions the smallest quantity of seed indicated may be used, while under less favorable conditions the quantity should be increased.

In seeding in mixture with oats or other small grain for hay, the quantity of vetch seed should be reduced about one-fourth, while the grain should be reduced to about one-half the amount used in seeding it alone. When the hay is to be used for horses, the proportion of grain should be much higher than when the hay is intended for cattle or sheep.

TABLE 1.—*Quantity of vetch seed to use per acre when seeded alone*

Kind	Southern States	Northern and Western States	Kind	Southern States	Northern and Western States
	Pounds	*Pounds*		*Pounds*	*Pounds*
Hairy	20–30	30–40	Narrowleaf	20–30	
Smooth	20–30	30–40	Purple		60–70
Common	40–50	60–80	Bard [1]		60–70
Hungarian	40–50	60–80	Woollypod	25–35	40–50
Monantha	30–40	60–70			

[1] Bard vetch is adapted only to the Southwest.

METHOD OF SEEDING

Vetches may be seeded either by broadcasting or by drilling. Broadcasting is the older method, but the use of the drill has greatly increased in recent years, especially in Oregon. Drilling has the advantage of being the more economical in the use of seed. Some growers have contended that there is less winter-killing when the seed is drilled. Experimental plantings, however, have not shown this difference.

The depth of planting varies with the type of soil. In loam soils good stands have been secured from plantings at a depth of 4 inches. Deeper planting will usually result in poorer stands, while shallower planting will give good stands when sufficient moisture is present. The surface-moisture condition should determine the depth of planting, which should not exceed 4 inches.

Vetch may be sown alone or with one of the small grains as a supporting crop (fig. 7). To sow with grain has been, and still is, the commoner practice where the crop is grown mainly for forage, as the grain furnishes a support for the weak stems of the vetch and to a considerable extent prevents lodging. Where oats succeed they are the favorite grain to use in combination with vetch, though wheat, rye, and barley may be used. Oats are especially serviceable when the crop is grown for seed, as the oat seed can be readily separated from the vetch seed, while there is greater difficulty with rye, wheat, or barley.

In Oregon, when grown as a seed crop, vetch sometimes is sown alone, but the price for threshing vetch alone in comparison with vetch with oats or other grain is the determining factor in this practice. In the sandy lands of Michigan, where the winters are severe, vetch is seeded in combination with rye. Where vetch is used mainly as a green-manure crop it is nearly always sown alone.

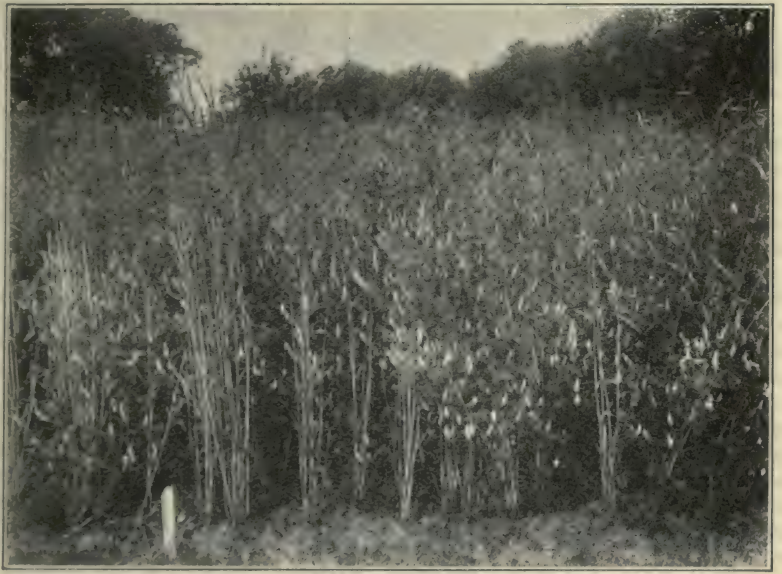


FIGURE 7.—Hairy vetch in mixture with rye, showing the general habit of growth of the vetch.

In the Cotton Belt, where vetch is used as a winter green-manure crop, seeding is done both by broadcasting and drilling. The green-manure crop follows cotton, and the seeding is made in the cotton middles. When the seed is broadcast it is covered with a 1- or 2-horse plow or cultivator equipped with disks or plows that cover the seed. If the seed is drilled, a 3-row 1-horse drill is often used. As the middle of the row is usually low and vetches will not grow well under such conditions, the middle hole should be closed when the three-row drill is used. For hairy vetch and others with seed of similar size the sorghum plate should be used in the drill. Some farmers go twice to the row with a one-row drill or with a fertilizer distributor that sows a mixture of seed, soil, and basic slag. Superphosphate is not mixed in this way because of danger of killing the inoculating organism. To avoid injury to the cotton, the drilling should be done immediately following a picking. In the lower part of the Cotton Belt the cotton is picked out before the vetch is planted. This will often permit the use of a large drill.

Furrows made by the small plows on the one-horse drills should be filled by the use of a smoothing attachment, such as a scratcher, chains, or a small chain harrow, to prevent the young vetch plants being covered with dirt and sand by the first heavy rains. This danger is greatest on sandy lands.

FERTILIZERS

In the Pacific Coast States fertilizers usually are not necessary for the successful growth of vetch. In western Oregon, however, gypsum or land plaster commonly applied at the rate of 75 to 150 pounds per acre is often used with beneficial results. In the Southern States east of the Mississippi River it is almost universally necessary to use fertilizers. Superphosphate seems to be the one thing especially needed, but in planting vetch for the first time on land that has not grown legumes or received applications of nitrogen in commercial fertilizers, nitrogen in some available form should be included. For most parts of the South, the use of from 300 to 400 pounds of 16-percent superphosphate per acre is recommended. This should be applied to the land preceding the planting of the vetch.

Nitrogenous fertilizers are seldom used, as inoculated vetch plants utilize the nitrogen of the air. By analysis vetch contains 2½ to 3½ percent of nitrogen, much of which is from the air; in other words, a ton of dry vetch contains about 60 pounds of nitrogen. A considerable proportion of this nitrogen is returned to the soil when the crop is harvested as hay and fed on the farm. If it is found necessary, however, to use nitrogen, nitrate of soda or sulphate of ammonia at the rate of 100 pounds of the ordinary commercial form per acre probably will be sufficient. Well-rotted barnyard manure at the rate of 15 to 20 tons per acre is one of the best fertilizers to insure a stand and good growth of vetch on land that has not grown this crop before, and much better inoculation has been secured on land receiving a good application of barnyard manure. Little, if any, additional fertilizer is needed on lands regularly fertilized for a summer crop of cotton or corn.

INOCULATION

Inoculation is essential to the growth of all vetches, and the grower of vetch should make certain that the organism necessary to accomplish this is present in the soil in adequate numbers before omitting the use of artificial culture or inoculated soil. In the Pacific Coast States vetch is nearly always naturally inoculated, the necessary bacteria apparently being present in the soil.

In the eastern part of the United States it is advisable to introduce the proper nodule organisms artificially unless it is known that they are already present. Many failures with vetch are directly attributable to the lack of inoculation. Inoculated plants are easily recognized by their greener color and more vigorous growth and by the nodules on their roots.

Inoculation can be accomplished by the use of commercial cultures or by the use of soil from fields that have grown a successful crop of vetch within the past 2 years. When soil is used, it may be mixed with the seed at the rate of a half bushel or more per acre and drilled with an ordinary drill or with a "knocker" fertilizer distributor. The soil should be air-dried in the shade and sifted to make it run freely, or it may be applied broadcast at the rate of 500 pounds per acre and worked into the soil just before seeding. Many farmers consider it good insurance to use both the commercial culture and soil.

Fertilizer is one of the essentials in effecting inoculation and good subsequent growth. Commercial fertilizer other than basic slag should not come in contact with inoculated seed, as it may injure the inoculating organism; however, a general application of fertilizer preceding or at the time of seeding is essential to success in many sections. If the summer crop preceding the vetch has been well fertilized, the quantity applied to the crop can be greatly reduced or in some cases entirely omitted.

When vetch is grown for the first time on land that is not naturally inoculated, the use of 300 pounds of superphosphate per acre and a light application of nitrogen is usually essential. Barnyard manure is very effective in bringing about inoculation and should be used whenever available.

WINTER-KILLING

The general winter-hardiness of the various vetches and their regions of adaptation is discussed under the heading "Climatic Requirements." It should be further noted that winter-killing in any variety of vetch cannot be connected with any definite temperature. The age, rate of growth, and vigor of the plant, the soil moisture, and winter protection are all factors directly involved in winter-killing.

Young plants from late seedings are often winter-killed when older plants of earlier seedings escape without injury. Plants growing rapidly because of high temperatures and ample moisture are injured more by freezing weather than plants that have been growing slowly and have had a gradual approach to a period of freezing.

The amount of moisture in the soil seems to have some relation to winter-killing. Seedings on wet lands will kill more easily than on well-drained land. This may be due in part to the effects of difference in soil-heaving, but most vetches do not thrive in soils that are wet during the winter months. Snow or any other loose covering lessens winter-killing. This is because a more uniform temperature is maintained about the plants and there is less soil-heaving.

HARVESTING FOR HAY

Vetch is ordinarily cut for hay when the first pods are well developed. When the crop is thin, cutting may be satisfactorily accomplished with an ordinary mower with a swather attachment (fig. 8). It is difficult, however, to cut heavy green vetch and use the swather. After being cut, the vetch should be windrowed with a side-delivery rake, if a swather is not used, or bunched with a horse rake and then shocked with pitchforks. This handling should always be done before the leaves are dry. Vetch should be allowed to cure in the shocks several days, and, if possible, hay caps should be used if rainy weather is feared. When a swather is not used, the harvesting is considerably more difficult. In either case it is the common practice to allow the vetch to lie a day before shocking. With most vetches it is difficult to obtain a bright-green-colored hay. Hungarian vetch is the best in this respect, and hay of this species handled properly can be cured so that the color is practically the same as when green.

When vetch is grown with a small-grain crop it should be cut for hay at the stage of its development just described. At that time the grain (if suitable varieties are used) will be in the milk or early soft-dough stage and will make good hay. Some growers make a difference in the time of cutting vetch, or vetch and grain hay, according to the class of livestock to be fed. For horses it is usually allowed to become more nearly mature than for either cattle or sheep.

It is sometimes desirable to pasture fall-sown vetch in the spring, in order to retard the haying season and also to prevent heavy lodging. This is often done in western Washington and western Oregon.

The yields of hay of the various commercial vetches are more or less comparable when they are grown under conditions to which they are entirely adapted. From 1½ to 3½ tons per acre is the usual range.

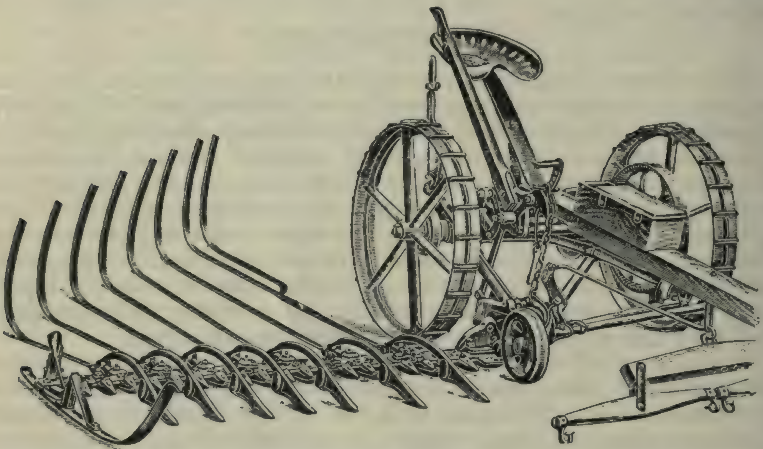


FIGURE 8.—A mowing machine equipped with lifter guards and a side-delivery bunching attachment for harvesting lodged vetch.

HARVESTING FOR SEED

The general practice is to cut common, hairy, smooth, woollypod, and other shattering vetches for seed as soon as the lower pods are fully ripe, at which time the upper pods will be fully formed and the plant will be carrying a maximum quantity of seed. Later cutting occasions more shattering of the seed, while earlier cutting results in a considerable percentage of immature seed. The practically non-shattering species, such as purple and Hungarian vetches, usually are allowed to ripen 75 to 90 percent of the pods before cutting. In places where but little seed is raised, the crop usually is cut with an ordinary mowing machine. Two men with pitchforks follow the mower and roll the vetch back from the uncut area, enabling the machine to get through when cutting the next swath. Sometimes the first-cut swath is rolled on the uncut vetch, and when the succeeding swath is cut the two are rolled back out of the way. This puts the vetch in larger swaths than the first-mentioned method and also may reduce the loss from shattering.

An ordinary grain binder is used by some growers, especially when the vetch is short and therefore quite erect or thin or when it is grown with a supporting crop, such as oats. When thus harvested the crop is put in shocks similar to grain shocks and allowed to dry thoroughly before being threshed. When the binder is used, however, the vetch should be cut a little greener than otherwise would be the case, as there will be some shattering of the pods caused by the canvases and packers. The bundles should be tied loosely so the material will dry rapidly and not mold.

The most common way of harvesting vetch at present in the Pacific Coast States is to use an ordinary mower with a swather attachment. The swather, which is attached to and behind the sickle bar, rolls the vetch in a swath to the outside and leaves the way clear to cut the next swath. The vetch is put at once into shocks and remains there until threshed, unless a combine with pick-up attachment is used, in which case the vetch is left in the windrow. Easily shattering kinds, like hairy vetch, should be shocked immediately after cutting.

The most important rule in the growing of vetch seed is to handle the crop as rapidly and as little as possible when cut.

In the southern part of the Cotton Belt, where vetch seed usually develops poorly, an occasional grower harvests hairy-vetch seed. In this section the pods do not break open readily and the crop can be allowed to become dead ripe, allowing the vines with the pods to be raked from the field and threshed.

Vetches vary considerably in the yield of seed per acre. Common, Hungarian, monantha, and purple vetches in the Pacific Northwest probably average from 10 to 12 bushels of seed per acre, while 20- to 25-bushel yields are near the maximum. In that region hairy, smooth, and woollypod vetches yield about 6 to 7 bushels as an average yield and from 12 to 15 bushels as the usual maximum.

THRESHING

An ordinary grain thresher can be used for threshing all kinds of vetch, whether grown alone or in combination with a small grain. Vetches thresh somewhat slowly, and the cost per bushel is much greater than for either wheat or oats. The charge for threshing seed is usually by the hour. It is sometimes necessary, in order to prevent cracking of the seed, to remove a number of the concave and cylinder teeth of the thresher and to reduce the speed of the cylinder to 800 or less revolutions per minute. The adjustments that may be necessary seldom can be told beforehand and must be determined by the appearance of the threshed material as it comes from the machine. The screens that come with ordinary grain threshers can be used by properly adjusting them. The seed as it comes from the thresher, however, seldom will be sufficiently clean for marketing and will have to be run through special cleaners, in order to secure a first-class product.

Combine harvesters are being used quite satisfactorily in the Pacific Northwest in harvesting the nonshattering or semishattering vetches. These machines are equipped with attachments which pick up the cut material from the windrow and pass it on to the separating machinery. Combining standing vetch is not considered satisfactory, because of heavy shattering loss.

CLEANING SEED

Vetch seed, as it comes from the thresher, will contain more or less cracked seed, small straws, weed seeds and stems, chaff, and the small grain with which it may have been grown. Ordinary fanning mills and seed cleaners, usually available on farms or at warehouses, will separate readily most of the foreign matter and trash from vetch. These machines will also separate quite readily the seeds of vetch and oats or barley, but wheat and rye seeds are not so readily separated from vetch seed. Separation of these, however, can be satisfactorily accomplished by the use of a gravity spiral seed separator (fig. 9), of the type recently introduced into general use in various regions growing vetch seed. Monantha-vetch seed is more difficult to clean than that of most other vetches because of its flattened and somewhat oval shape and variations in size. When this seed is mixed with other kinds of vetch or with wheat it is often necessary to rely very largely on the spiral cleaner to separate them effectively.

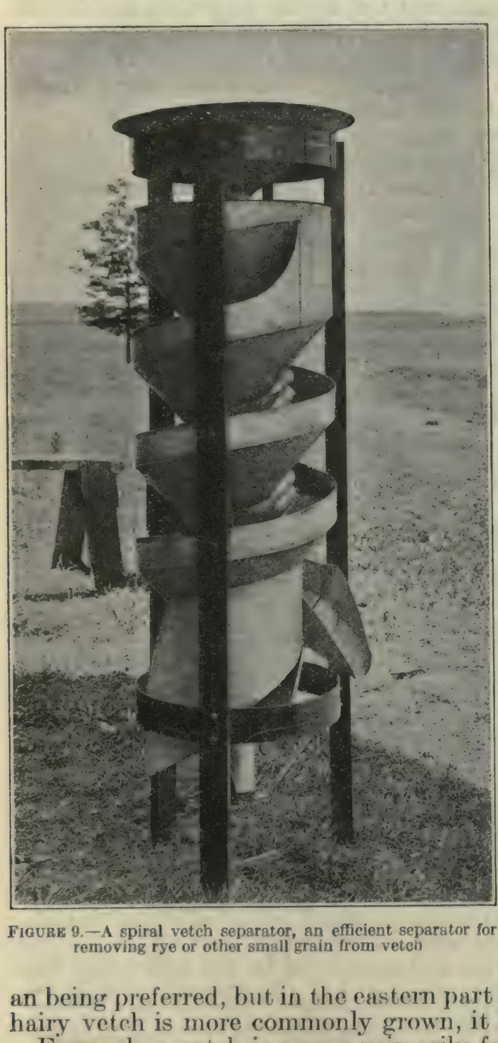


FIGURE 9.—A spiral vetch separator, an efficient separator for removing rye or other small grain from vetch

PASTURING

Common, hairy, and Hungarian vetches have been used for pasturage. Common and Hungarian are utilized by Oregon and Washington dairymen for pasturage during winter, spring, and early summer and are eaten eagerly by all farm livestock. As a general rule, vetch is pastured only when the ground is dry, to avoid packing the soil and to reduce the possibilities of bloat in cattle and sheep. Hairy vetch is used but little for pasturage in Washington and Oregon, the common and Hungarian being preferred, but in the eastern part of the United States, where hairy vetch is more commonly grown, it is pastured to some extent.

Even when vetch is grown primarily for hay or for seed, a limited amount of pasturing is often desirable, especially where the growth is likely to be unusually rank or where it is desirable to make the harvest later. Hogs should not be used for this purpose, as they destroy many of the plants by biting them off below the crown. Sheep and calves do the least damage in pasturing vetch to be used primarily for hay or seed crop.

SOURCES OF SEED

Most of the seed of common, Hungarian, purple, and monantha vetches used in the United States is produced in this country. While considerable seed of hairy and smooth vetches are produced in the United States, large quantities are imported. The seeds of both kinds come in under the name hairy vetch, as they are indistinguishable.

Hairy vetch is produced in Europe in the countries bordering the Baltic Sea and south to Hungary; common vetch is produced in the more southern European countries and in the British Isles; bittervetch seed is produced in the Mediterranean region, especially in the eastern part, where it is used as stock feed. So far as known, Hungarian and monantha vetches are produced only in very limited quantities in southern Europe.

In the United States hairy-vetch seed is produced in Michigan, western Oregon, and western Washington; common and Hungarian in western Oregon and western Washington; monantha and purple in western Oregon, western Washington, and northwestern California; smooth in western North Carolina; and woollypod vetch in western Oregon.

The production of vetch seed depends somewhat upon the commercial price, which in the past has been subject to decided fluctuations. Vetch reached a maximum price in 1919, when the grower received about 8 cents a pound for common and about 21 cents a pound for hairy. The minimum prices received by the grower have been about 1½ cents a pound for common and 5 cents a pound for hairy. Prices for Hungarian, monantha, and purple have ranged about the same as those for common vetch. Those for smooth and woollypod vetches have been about the same as those for hairy vetch.

LONGEVITY AND HARD SEED

Vetch seed with low moisture content retains its vitality under average conditions for a number of years. Germination tests made at Corvallis, Oreg., show that locally grown seed, of the species tested, retains its vitality with little or no decrease through a 5-year period and that seed much older often gives good germination. Seed with high moisture content, however, deteriorates rapidly. This is especially true when temperatures are high, as in summer or in warm climates. For this reason, all seed should be given a germination test before planting.

The species of vetch differ with respect to the proportion of hard seed they contain. Common, Hungarian, purple, and monantha vetches have little or no hard seed, while hairy, smooth, and woollypod vetches usually have from 5 to 25 percent.

VETCH IN ROTATIONS

In the Cotton Belt vetch serves well as a winter crop, to be followed by corn, cowpeas, soybeans, sorghums, millet, or any late-planted crop. When the summer crop can be planted very late, it is possible to utilize the vetch for winter and spring pasture or hay. If the summer crop must be planted early, the vetch should be utilized as winter pasture or green manure, or as a combination of the two.

In the Northern States it is sometimes possible to cut fall-sown hairy vetch early enough for hay, so that a late crop of millet can be grown. Other vetches in the North must be spring sown; they require the entire summer season for development.

Under irrigation in the Southwest, where the winters are mild, it is possible to grow vetch alone or in combination with a grain crop for hay or pasturage during the winter and then grow a summer crop.

In the Northwest an entire season has to be given over to the vetch, but it is recognized as an excellent crop to use in rotation with the small grains and cultivated crops for the maintenance of soil fertility.

FUNGOUS DISEASES

While there are several fungous diseases reported as occurring on vetch, it is seldom that any of these do serious damage. Leaf spot (*Ascochyta viciae*) can usually be found on all species of vetch, but this does little damage. On the Pacific coast during recent years, stem rot (*Sclerotinia trifoliorum*) has caused some loss. During wet, warm springs, plantings made alone which have attained a heavy growth are attacked, and some loss occurs. The disease spreads slowly, however, and seldom damages large areas, but it occurs in spots most favorable for its inroads. Land on which stem rot has attacked vetch should not be seeded to this crop again for a period of at least 3 years.

In Florida serious damage to early-fall plantings of vetch by *Rhizoctonia* sp., has been noted at the Florida Agricultural Experiment Station. At other places in the South, *Protocoronospora nigricans* has been noted as doing considerable damage to nearly mature vetch, but it does little damage in the earlier stages of growth.

INSECTS AND NEMATODES

Many insect pests of alfalfa, clover, and other forage legumes also attack vetch. Among the more important of these are aphids, the corn earworm, grasshoppers, cutworms, the fall army worm, various weevils, and leaf hoppers. The control of these pests on vetch is for the most part similar to the control of such insects on other forage legumes. Information is usually available on the biology and control of most of these insect pests, and although the damage caused by various species may look the same, the control measures are usually different. When injury is observed and information is desired, specimens of the insects causing the damage, together with a sample of the injured plant, should be sent to the State experiment station or to the Bureau of Entomology and Plant Quarantine, United States Department of Agriculture, Washington, D.C.

The vetch-seed grower's attention should be called in particular to aphids, and he should be on the lookout for these little insects in the spring, as they multiply rapidly as the weather becomes warmer and the crop develops and may damage a crop seriously in a very short time. When it seems probable that aphids will destroy the vetch, it is advisable to cut the crop promptly, as a considerable amount of hay may thus be saved. In the Cotton Belt serious damage may be done to a vetch green-manure crop if it is allowed to continue growth too late in the spring. The proper season, however, for turning under the green-manure crop for cotton or corn is sufficiently early to avoid serious damage. In the northern part of the Cotton Belt, aphid damage may be expected after April 15 and in the southern part after the last of March or early April. When aphids appear in abundance, the green-manure crop should be turned under or disked down at once. In the South, the corn earworm sometimes does serious damage to maturing or late-standing vetch. This subject is treated fully in Farmers' Bulletin 1206, "The Corn Earworm as an Enemy of Vetch."

All the commercial and other varieties of vetch as far as known are subject to attack by nematodes, and at times serious damage may result. Nematodes are most active in warm weather, and serious damage may be avoided by planting moderately late. In the Cotton Belt this means the last of September or early October, which will bring the growing season into the cooler part of the year.

COMMERCIAL VETCHES IN THE UNITED STATES

While hairy, common, and Hungarian vetches are the kinds most commonly used in the United States, others are used in limited areas and some of these offer possibilities of more extended use. To supplement the previous more general discussion, a short agronomic description of the different kinds of vetch is given.

HAIRY VETCH

(*Vicia villosa* Roth.)

Hairy vetch, one of the oldest and most commonly used of the vetches, is grown in practically all the countries in the Temperate Zone and is extensively used in the United States. The stems are comparatively weak or viny, and the plants are conspicuously hairy throughout. This vetch is very winter-hardy and will stand the winter temperatures of the northern part of the United States except in areas where the ground is usually or often bare during the winter months and so affords little or no protection to the vetch plants. Hairy vetch is grown as a seed crop in parts of Michigan and in western Oregon. Seed also is grown in quantity in the European countries bordering on the Baltic Sea and is imported into the United States from that region.

SMOOTH VETCH

(*Vicia villosa* Roth.)

Smooth vetch is rather like hairy vetch in general, but differs in lacking the tufted growth at the ends of the stems and in having fewer hairs or less pubescence on stems and leaves. The seed is very much like that of hairy vetch and appears identical, and the two kinds are being sold under the name "hairy vetch", and often in mixture. Smooth vetch seems to be somewhat less winter-hardy than hairy vetch, although their exact relation in this respect has not been determined.

In the Southern States, smooth vetch has made somewhat more growth than hairy vetch during the winter months and is perfectly hardy throughout that region. Seed is grown commercially in North Carolina and it is well adapted to the Cotton Belt as a winter green-manure and forage plant. Seed is imported under the name "hairy vetch."

WOOLLYPOD VETCH

(*Vicia dasycarpa* Ten.)

Woollypod vetch, which is similar to hairy and smooth vetches, is more nearly like smooth vetch, and without the flowers and seed can hardly be distinguished from that variety. The flowers are a little smaller than either those of hairy vetch or smooth vetch, and the seed tends toward an oval shape instead of being nearly round, as in those varieties. The seed scar also has distinguishing marks which are apparent to the seed expert. The plant is comparatively smooth or lacking pubescence. In winter-hardiness, woollypod vetch is comparable with smooth vetch, although possibly a little less winter-hardy. It seems to be perfectly winter-hardy throughout the Cotton Belt and as far north as Washington, D.C.

Seed of woollypod vetch has been grown in western Oregon in very limited quantities and is not regularly available. This species makes a good winter growth in the South, and with cheap seed there is no reason why it should not be used for green manure and forage.

COMMON VETCH

(*Vicia sativa* L.)

Like hairy vetch, common vetch is of ancient origin. The plants are semiviny, having slightly larger leaves and stems than hairy vetch. Being less winter-hardy than hairy vetch, common vetch cannot be grown as a winter crop except in regions having a mild climate. In western Oregon and western Washington it is hardy in most winters, but it often winter-kills in the northern part of the Cotton Belt. Its commercial use is confined to the Pacific Coast States, where it is grown as a hay and seed crop, as well as for green manure, silage, and pasturage. There are a large number of varieties of common vetch, among which the one commonly grown for seed in western Oregon is one of the most winter-hardy. Pearl vetch is a variety of common vetch with light-pink seed, which is grown occasionally in western Oregon as a spring-sown crop.

HUNGARIAN VETCH

(*Vicia pannonica* Grantz.)

Hungarian vetch is a native of central Europe, being rather abundant in Hungary and adjoining territory. It has been introduced into cultivation in Europe but is less extensively grown than hairy or common vetch. This vetch is grown in western Oregon, where it has recently become of commercial importance. The plants are less viny than hairy vetch or common vetch and tend to be erect when the growth is short or when the plants have some support. Both the stems and the leaves are covered with medium-long hairs, which give the plants a decidedly grayish color. A stem length of from 3 to 4 feet is attained under favorable conditions, but under average conditions 2 to 2½ feet is more common. Hungarian vetch is rather winter-hardy and is comparable with smooth and woollypod vetches in this respect. Its exact limitations have not been determined, but it has survived winters as far north as Washington, D.C., without injury.

Hungarian vetch is especially well adapted to heavy clay soils and will do better in wet situations than other vetches. In the Southern

States it has done poorly on sandy land. The seed habits of Hungarian vetch are good, and comparatively heavy yields of seed are obtained. Its commercial use is confined almost wholly to the Pacific Northwest, where it is grown as a hay, silage, green-manure, pasture, and seed crop. The seed is used to a limited extent in mixed ground feeds.

MONANTHA VETCH

(*Vicia monantha* Desf.)

Monantha vetch is a native of southern Europe in which region it has been brought under cultivation, but as far as known it is used only in a very limited way. The plant is weak-stemmed and viny, being like hairy vetch in this respect. In comparison with other commercial vetches, it has very fine stems and leaflets and matures early.

Monantha vetch is not very winter-hardy, and for this reason it is adapted only to regions having mild winter climates. In the Cotton Belt, where winter temperatures are subject to great fluctuations, it has not been found regularly hardy except in the extreme southern part. In the Pacific Coast States it has survived the winters in the milder parts of Washington, Oregon, and California. At the present time, monantha vetch is grown in a limited way for seed in northwestern California and in western Oregon. In orchards of Florida and southern Georgia, and to some extent in California, it is used for winter green manure. The seed habits of this vetch are good, and seed yields are comparatively heavy. Wherever it can be grown it will make a good green-manure and forage crop.

PURPLE VETCH

(*Vicia atropurpurea* Desf.)

Purple vetch is a native of southern Europe; from there it was introduced into the United States. It is a viny plant with much the habit of growth of hairy vetch but differs from that variety in pod and seed characteristics. Purple vetch is one of the least winter-hardy of the commercial vetches and for that reason is restricted in its range of usefulness. In the milder parts of California it is winter-hardy, but in western Oregon and Washington it occasionally winter-kills. In the Cotton Belt, purple vetch has proved entirely unsuited, as it cannot stand the fluctuating winter temperatures. In this region it winter-kills severely, except in the extreme southern part of Georgia and Alabama, and even there it occasionally will be severely injured.

Purple vetch has been grown as a seed crop in western Oregon, western Washington, and in northwestern California. In other parts of California it has been used as a green-manure crop. At the present time, however, it is not so extensively used as formerly. The seed habits are good and seed yields comparatively heavy.

BITTERVETCH

(*Vicia ervilia* (L.) Willd.)

Bittervetch is not grown in the United States, but is grown in parts of southern Europe and in Asiatic Turkey. The plants are more nearly upright in growth than most other vetches, although it lodges easily when making a rank growth. The seeds are conical or pyramidal in shape and smaller than those of Oregon common vetch. In the western part of the United States this vetch has made good growth and has produced good crops of seed, but it has never been considered superior to other vetches in common use. The seed is used for stock feed, especially for sheep. In the Cotton Belt it has made comparatively little growth and often has winter-killed, indicating that its use in that region will be limited. It makes very good growth in the Pacific Northwest and produces heavy seed crops.

NARROWLEAF VETCH

(*Vicia angustifolia* Grufberg.)

Narrowleaf vetch, like the other commercial vetches, is of European origin, occurring in the United States mostly as a weed. Closely related to common vetch, it is very much like that species, but usually is distinguishable by its black pods, narrow leaflets, and smaller flowers. In the grainfields of the Spring Wheat Belt, it is found in abundance, and in the Cotton Belt it is everywhere along roadsides and in waste places wherever there is an accumulation of weed growth. Elsewhere in the United States it occurs in lesser abundance but usually persists by volunteering.

Seed of narrowleaf vetch is not regularly available in the seed trade. Occasionally it is harvested from volunteer stands in the South and saved from the screenings of the spring-wheat crop in the Northwest.

A few orchardists of the South have found this a good crop for volunteering as a winter-cover and green-manure crop. The crop seems to succeed, however, only where there is good soil or where there is weed growth and an accumulation of organic matter. It volunteers in pasture lands and makes excellent pasturage. Under cultivation, narrowleaf vetch has seldom succeeded.

BARD VETCH

(*Vicia calcarata* Desf.)

The general habit of growth of Bard vetch is similar to that of hairy and common vetches. It has succeeded well in the irrigated areas of the Yuma and Imperial Valleys of the Southwest, where a very small acreage is grown. Farther north in the West, it cannot compete with the other vetches, and in the Cotton Belt east of the Mississippi River it has never succeeded.

HORSEBEAN

(*Vicia faba* L.)

Horsebeans, coarse, upright-growing plants having large, broad leaflets and large pods, differ decidedly in habit of growth from most of the vetches. There are many varieties of this species, most of which are grown for their seed. The small-seeded varieties are sometimes grown for green manure, but are more generally used as stock feed; the large-seeded varieties are used as a vegetable. Formerly a large acreage of horsebeans was grown in California, but at present the acreage is rather small; in other parts of the country horsebeans are occasionally grown as a home-garden vegetable.

The horsebean requires a cool season for its best development, and it is grown as a winter annual in the South wherever it will not winter-kill. In the North it is not winter-hardy, and even in the South it cannot be grown successfully where the temperatures fluctuate rapidly.

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U. S. DEPARTMENT OF AGRICULTURE
FARMERS' BULLETIN No. 1741

BUR-CLOVER CULTIVATION *and* UTILIZATION

BUR-CLOVERS are winter annual legumes and are used for pasturage and green manure. They are valued particularly because they so readily maintain themselves with little or no reseeding and because each year they can be depended on to add humus and nitrogen to the soil without sacrificing the regular summer crop of the farm.

Mild climatic conditions are essential for the successful growth of these plants. They require moderately fertile soil and when grown on poor land should receive an application of 400 pounds per acre of superphosphate or complete fertilizer high in superphosphate.

Seedings should be made sufficiently early in the fall so that the plants will become well established before winter. Seedings can be made broadcast or with a drill, 5 or 6 bushels of seed in the bur being used for broadcasting or 15 pounds of hulled seed for drilling. The seed should be hulled and scarified or given the hot-water treatment to make the hard seed germinable and to insure good stands.

Inoculation is essential in the Southern States except on lands that have grown bur-clover successfully. Most soils in the West seem to be well inoculated.

Bur-clover affords excellent pasturage and at low elevations on the range lands of California is one of the principal plants.

Where bur-clover can volunteer from year to year in cultivated land it affords one of the best and cheapest cover crops. When the crop is harvested for seed the burs are allowed to mature and drop to the ground, and are then swept together with barn brooms.

Spotted bur-clover yields from 150 to 350 pounds of hulled seed per acre, and California bur-clover yields from 30 to 500 pounds.

Where bur-clover succeeds in the South, and can volunteer, it is the least expensive winter cover crop to seed in cotton and corn. Its use as a cover crop prevents the washing of the soil.

This bulletin is a revision of and supersedes Farmers' Bulletin 693, Bur Clover.

Washington, D. C. Issued December 1934

BUR-CLOVER CULTIVATION AND UTILIZATION

By ROLAND MCKEE, *senior agronomist, Division of Forage Crops and Diseases, Bureau of Plant Industry*

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INTRODUCTION

BUR-CLOVERS are annual legumes, much like ordinary clovers, but the small yellow flowers are in clusters of 5 to 10, and the coiled pods are commonly beset with spines, thus forming the so-called "bur." The roots are fibrous and do not extend very deep. Most of the plants are branched at the crown, and have 10 to 20 or more spreading or decumbent branches 6 to 30 inches long, which when in fruit are thickly beset with burs. Well-developed plants may contain more than 1,000 pods. Bur-clovers are valuable agriculturally only where the winters are mild—in the United States in the cotton-growing area of the South and all of the Pacific coast west of the Cascade and Sierra Nevada Mountain Ranges.

Bur-clover is highly regarded particularly because it so readily maintains itself with little or no reseeding, and because each year it can be depended on to add humus and nitrogen to the soil without sacrificing the regular summer crop of the farm. For the South, especially, bur-clover is the cheapest legume that serves as a winter cover crop, thus preventing the washing of the soil. In addition to its value as a winter cover crop, it furnishes some pasturage and improves the soil. Many instances are reported in which the cotton crop has been materially increased each season by the use of bur-clover alone.

KINDS OF BUR-CLOVER

There are two species of bur-clover commonly cultivated in the United States, namely, the spotted or southern bur-clover (*Medicago arabica;* fig. 1) and the California or toothed bur-clover (*M. hispida;* fig. 2). Tifton bur-clover (*M. rigidula*) is a more recently introduced species that has been grown and distributed from the Georgia Coastal Plains Experiment Station, located at Tifton, Ga., but has not yet become established commercially. Another species, *M. minima*, has been naturally introduced in a number of places in the Southern States and is gradually spreading. *M. minima* is comparable with spotted bur-clover in winter hardiness, but Tifton bur-clover is the most hardy of all and usually will survive most winters as far north as Washington, D. C.

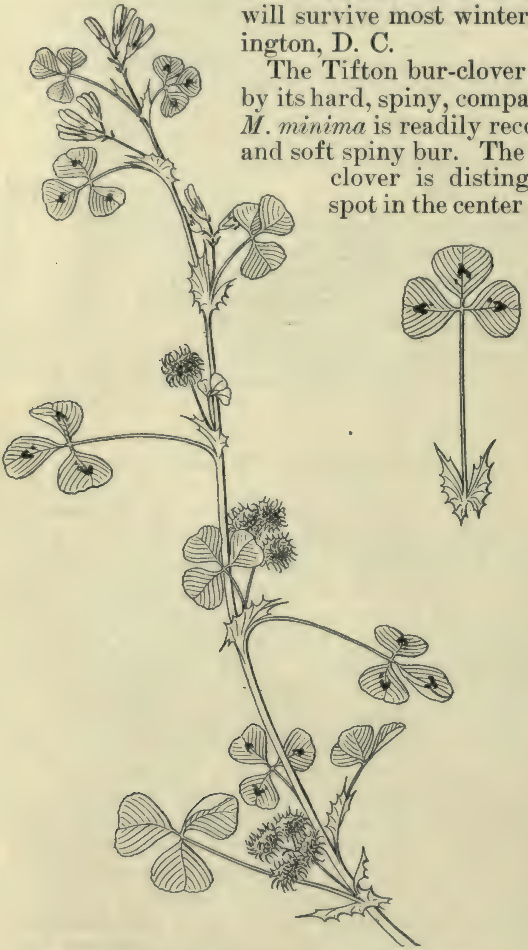

FIGURE 1.—Spotted bur-clover (*Medicago arabica*).

The Tifton bur-clover is readily distinguished by its hard, spiny, comparatively large bur, while *M. minima* is readily recognized by its very small and soft spiny bur. The spotted or southern bur-clover is distinguishable by the purple spot in the center of each leaflet. Toothed bur-clover has no outstanding features; it is readily distinguished, however, from the spotted bur-clover, which it most nearly resembles, by the lack of the large brown spot in the center of the leaf and differences in bur characters (figs. 3 and 4). A pod of spotted bur-clover contains from 2 to 8 seeds; in California bur-clover the usual number is 3, but there are often as many as 5.

In addition there are about 35 other species, some of which have large, smooth burs, while others have very hard and spiny burs. All of these are native to the Mediterranean region, although a few occur naturally as far eastward as Turkistan. There is a variety of the spotted bur-clover with spineless pods, and several similar varieties of the California bur-clover. These, together with others with large spineless burs, as buttonclover (*M. orbicularis*), snailclover (*M. scutellata*), and tubercled clover (*M. tuberculata*), have been tested to determine their value as compared with the spiny varieties.

VALUE OF SPINELESS BUR-CLOVERS

In experimental plantings under cultivation, the spineless, spotted, California, and other bur-clovers have all made good growth and matured good crops of seed. Under pasture conditions they have made good growth and matured seed when not grazed too closely during the fruiting season. Experience has shown, however, that the varieties with large spineless burs cannot be maintained in pastures except when given special attention and protection. The seed of spineless varieties with small burs escape grazing animals more readily and, consequently, are more persistent, and are not uncommon in California.

Since the spiny varieties of bur-clover are now widely distributed in areas where bur-clovers are adapted, any plantings of spineless varieties would soon be mixed with those having spines. It appears, therefore, that there is no practical value in these spineless forms.

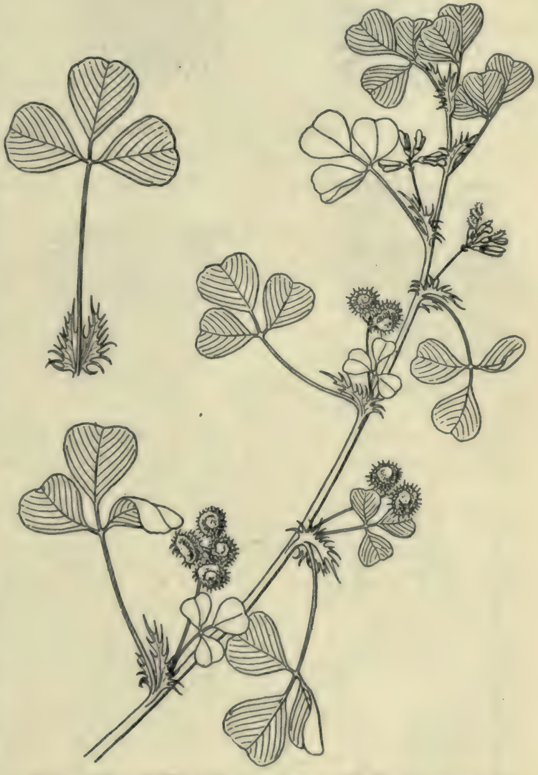

FIGURE 2.—California bur-clover (*Medicago hispida*).

CLIMATIC ADAPTATIONS

All of the bur-clovers are normally winter annuals; that is, in the country to which they are native they germinate in the autumn, grow during the fall, winter, and early spring, and mature early in the summer. They are thus primarily adapted to regions with mild, moist winters, and in this country maintain themselves naturally only in the areas shown by the shading in figure 5. Northward from the areas indicated they succeed fairly well when the seed is sown in the spring, but are scarcely able to maintain themselves by reseeding from year to year.

On the Pacific coast, especially in California, along streams and in shady situations, spotted bur-clover is now nearly as abundant as California bur-clover. In the Southern States spotted bur-clover is decidedly better adapted to the conditions than California bur-clover. The latter, however, appears able to maintain itself from year to year in the less humid portions of eastern Texas and in parts of southern Oklahoma. There is also evidence to indicate that California bur-clover is destroyed in winter by temperatures that do little or no harm to the spotted bur-clover. The latter, therefore, is to be preferred in the cotton States, where California bur-clover cannot be so highly recommended. In the Pacific coast area from Oregon south to Arizona and in the Great Plains area of eastern Texas and southern Oklahoma bur-clover is a valuable winter annual pasture plant and is especially well thought of throughout that region for its high feeding value.

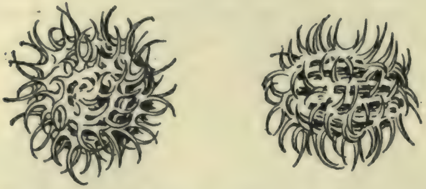

FIGURE 3.—Pods of spotted bur-clover.

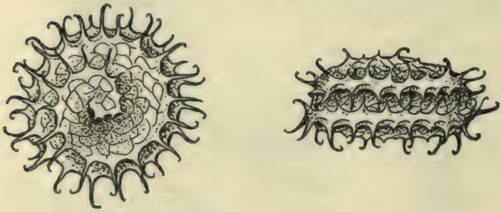

FIGURE 4.—Pods of California bur-clover.

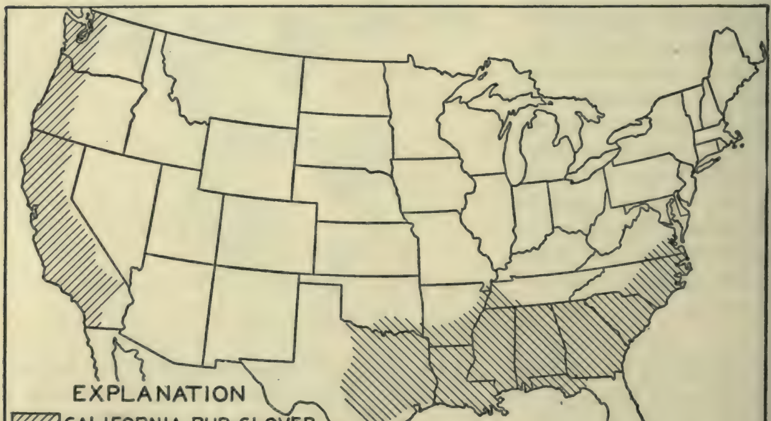
EXPLANATION
▨ CALIFORNIA BUR-CLOVER PARTICULARLY
▨ SPOTTED BUR-CLOVER PARTICULARLY

FIGURE 5.—Outline map of the United States, showing the regions to which bur-clover is adapted.

Bur-clover may be pastured in North Carolina by the middle of February, and near the Gulf coast it furnishes practically continuous winter pasturage. Few legumes will make more growth in that area during cool weather.

SOIL PREFERENCES

Bur-clover will succeed in practically all types of soil, but loams are most suitable. In the South the plants grow best in soils rich in lime, but they thrive well enough in soils poor in this substance. Apparently the plant is not indifferent to lime, but it will succeed in noncalcareous soils. As a rule it prefers moist, well-drained soils, but in California it grows vigorously in adobe soils, which are often poorly drained. Where the soil is very moist the plants mature much later than on well-drained land. The California Agricultural Experiment Station found that California bur-clover would grow luxuriantly in alkali soil containing 11,300 pounds of carbonate of soda to an acre in the top 30 inches. Apparently the plant is as tolerant of alkali as is barley. In general, bur-clover succeeds well in slightly alkaline soils, but not in those heavily charged with salts.

FERTILIZER REQUIREMENTS

Bur-clover does poorly on soils of low fertility. In establishing stands, except on very fertile soils, the use of liberal quantities of stable manure or commercial fertilizer is recommended. Usually superphosphate is the most essential fertilizer ingredient, and the use of 400 pounds per acre of this is all that is needed. In some cases potash is beneficial, and on very poor soils the addition of nitrogen will give increased growth.

TIME OF SEEDING

Bur-clover should always be sown in late summer or fall. In the cotton States the best time of seeding is the month of September when seed in the bur is used, but it may be seeded in August, and seedings as late as December may give favorable results, even as far north as South Carolina. Late seedings, however, are to be avoided whenever possible, as but little fall and winter growth is secured from such plantings. Hulled seed germinates more readily than seed in the bur, so that where hulled seed is used the time of sowing may be delayed on an average from 2 to 4 weeks longer than if seed in the bur is used.

In California, where the summers are always dry, seeding may be delayed until just before the fall rains begin. If the sowings are to be made on irrigated land, the best average date is about the first of October, since by seeding at this time only a single irrigation is ordinarily necessary; that is, the one made just before seeding. If the seeding is done earlier, a second irrigation may be necessary before the rains come; otherwise the young plants are likely to be injured by drought.

SOWING THE SEED

Hulled seed may be sown by a grain drill with a press-wheel attachment, or by any method of broadcasting, about 15 pounds of seed being used per acre. A firm seed bed is essential, and especial care should be taken to cover the seed thinly. Under most conditions broadcasting will be found most satisfactory, but the seed should be harrowed lightly. Where moisture conditions are entirely favorable, good stands have frequently been obtained by merely scattering the seed on the surface, but whenever practicable harrowing is recommended.

When the seed is sown in the bur, broadcasting is the only practicable method. To obtain a full stand by this method, from 3 to 6 bushels of seed per acre are necessary, followed by a harrowing.

In the regions that are well adapted to bur-clover it is much more economical as a rule to begin with a light seeding and to depend in subsequent years on the volunteer crop, where this is practicable.

GERMINATION OF THE SEED

Bur-clover seed in the bur retains its vitality for a number of years. Hulled seed deteriorates more readily but usually gives a high percentage of germination for 3 years or more. In all cases seed in the bur contains a high percentage of hard seeds, most of which do not germinate until the second year or later. Hulled seed usually germinates readily. On account of the high percentage of hard seed it contains, unhulled seed often gives poor stands, and for this reason hulling or special treatment to induce germination is recommended.

Independent investigations by McNair,[1] of the Office of Farm Management and Costs, Bureau of Agricultural Economics, United States Department of Agriculture, and by Duggar and Tisdale,[2] of the Alabama Agricultural Experiment Station, have shown that this difficulty of germination can be largely overcome by treating the seed in the bur with boiling water before it is sown. As a result of these investigations, the following method is recommended: (1) Empty a bag of the burs into a tub of cool water and let them stand for 2 hours, stirring occasionally to loosen as much dirt as possible for reinoculating the burs at the end of the hot-water treatment; (2) remove the burs from the tub of cool water, put them in a bag, and immerse for 5 minutes in a barrel of water almost scalding hot; (3) plunge the bag of burs for 1 minute in water kept boiling hot; (4) lift the bag of burs from the boiling water, plunge first into a barrel of cool water, and then empty into the tub of muddy water in which the seed was first placed. The muddy water tends to inoculate the burs, which have presumably had their inoculating bacteria killed by immersion in the boiling water. This inoculation is not necessary where the land to be planted is known to be already inoculated for bur-clover. Sow the seed immediately or spread it out to dry as rapidly as possible in an airy, shady place.

INOCULATION

On the Pacific coast, where bur-clover is established practically everywhere, inoculation is not necessary. In the cotton States, however, lack of inoculation apparently has often been the cause of failure in establishing bur-clover crops, especially where hulled seed was sown. Often when seed is sown in the bur there are enough bacteria in the dust on the burs to insure inoculation. It is desirable, however, in planting bur-clover for the first time, that farmers should not go to the expense of purchasing a large quantity of seed, but that a comparatively small area be planted, the soil being inoculated either by the soil-transfer method or, in the absence of inoculated soil, by the use of pure cultures. When once a patch of bur-clover has been successfully grown on a farm, the whole farm can be inoculated by scattering soil from the places where the bur-clover grew successfully.

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[1] McNair, A. D. BOILING BUR-CLOVER SEED TO HASTEN GERMINATION. Prog. Farmer [Raleigh, N. C.] 29 (38): 997. 1914.

[2] Duggar, J. F., and Tisdale, H. B. BUR-CLOVER SEED; MEANS OF HASTENING THEIR GERMINATION. Ala. Agr. Expt. Sta. Circ. 29, pp. 113–116. 1914.

SOIL-TRANSFER METHOD

The soil-transfer method is the surest known way to secure the inoculation of any legume. The soil should be taken from a spot where bur-clover is growing successfully or from fields of alfalfa, blackmedic, or melilot. The same germ inoculates all four of these plants, so that soil from near the roots of any one will inoculate the others. The soil should be taken from the top 8 inches and broadcast over the area to be planted at the rate of 500 pounds per acre. Care should always be taken to secure soil free from troublesome weeds or diseases.

On account of the expense involved and the danger of introducing diseases and insect pests, it is seldom advisable to get soil from a distance. It is better to sow but a small patch the first year, which, if successful, will supply abundant soil to use as inoculation for more extensive plantings. If stable manure is liberally used the chances of inoculation are greatly enhanced.

Sometimes inoculation is secured by dusting the seed with well-inoculated soil.

Even if a little seed is sown without inoculation, especially if the seed is in the bur, some of the plants are likely to have nodules on their roots. In this manner large areas of land may be gradually inoculated at merely the expense of a small amount of seed.

PURE-CULTURE METHOD

Pure cultures in glass containers may now be secured for nearly all legume crops. Where these are used, it is strongly recommended that only a small area be planted at first, and preferably on good or manured soil. As pure cultures frequently fail to provide inoculation, they should not be depended upon when large fields of a new legume are sown for the first time. Where soil is not available, however, they furnish the most convenient method of securing inoculation in small plantings.

VOLUNTEER CROPS OF BUR-CLOVER

One of the advantages of bur-clover over most other legumes is the fact that good stands can often be obtained from year to year without additional seeding. On pasture lands, where once established, bur-clover will reseed itself indefinitely.

On cultivated land the same thing is true, provided the land is not plowed until some of the burs have ripened. However, for most summer crops as commonly planted it is impractical to allow the bur-clover to remain on the land so long. This is particularly true of corn and cotton. With these and other row crops, stands of bur-clover for the succeeding fall can be secured when the plantings of row crops are in wide rows (4 to 5 feet) which make possible the seeding of the current year's corn or cotton between the old rows that are left as " balks " in which the bur-clover can mature and be worked down later.

With rows of cotton 6 or 7 feet wide it is possible to interplant with cowpeas or soybeans after the matured bur-clover has been plowed down. The dried bur-clover plants should be turned under rather shallowly, because, if the seeds are buried deeply, the stand will probably be thin. On the whole, however, it is better to grow the seed in a separate patch, gather it when ripe, and then sow in the cultivated crop where desired. Under some conditions bur-clover seed will retain its vitality in the soil for 2 or 3 years, so that where it once is well established volunteer stands are common.

BUR-CLOVER FOR PASTURES

Bur-clover is utilized mostly as pasture for hogs, cattle, sheep, and poultry. Farm animals do not eat it readily at first, but they soon acquire a taste for the plant and then eat it freely. In Argentina, where both the California and the spotted bur-clover occur, it is said that horses will eat the former quite readily but absolutely avoid the latter. No similar observations have been recorded for California, where the two species grow together. When bur-clover is growing in cultivated lands it is best not to pasture continuously, but to put the stock on the land for only a few hours each day, as this reduces very much the injury by trampling. Few cases have been recorded of bur-clover causing bloat, but where the growth is lush care should be exercised. Not only do animals eat the herbage, but sheep, especially, are very fond of the ripe pods and will lick them from the ground. Much of the value of range lands in California depends on the large crop of pods produced by the bur-clover, which remain in good condition a long time. When the burs are abundant in the pasturage, sheep fatten very rapidly. The spines bother the animals only slightly, but the burs are eaten more readily when they have been softened by rain.

For permanent pastures in the South, a combination of bur-clover and Bermuda grass is very satisfactory. The Bermuda grass furnishes pasturage during the warm weather until further growth is stopped by frost, whereas the bur-clover begins to grow with cool weather in the fall and provides pasturage during the winter and spring. Where once established on such pastures it reproduces itself continuously. On Bermuda-grass pastures where bur-clover is not established, it is recommended that furrows be plowed through the Bermuda grass from 5 to 10 feet apart and seed of bur-clover, preferably in the bur, be sown in these plowed furrows in September. Within a year or two the plants produced in these plowed furrows will seed the whole pasture. Disking such a pasture in summer tends to stimulate the Bermuda grass. Broadcasting about 1 bushel of bur-clover seed in the bur to each acre before disking the Bermuda grass will usually give a stand of the bur-clover.

USE AS A COVER AND GREEN-MANURE CROP

Bur-clover alone is commonly used as a green-manure crop in the orchards of California and is often so handled that good volunteer crops are obtained year after year.

In the South, undoubtedly the greatest value of bur-clover is the fact that it is the cheapest and most easily handled legume that can be used as a combination cover and green-manure crop. Even a growth only a few inches in height is sufficient to prevent to a large degree the washing of the land in winter and, when plowed under, to add sufficient humus and nitrogen to improve materially the following cotton crop. It is the most economical legume to use for this purpose, as when once a stand has been secured and rows of the plants are left to seed it will volunteer from year to year. The same method can be used with corn or any other intertilled summer crop. There is some difficulty in seeding bur-clover in standing cotton, as in the harrowing of the bur-clover seed some of the ripe cotton is pulled out of the bolls. For this reason, the harrowing should be done just after the pickers have been through the field, thus avoiding as far as possible any injury to the opened bolls.

There are several well-authenticated farm records which show that by using bur-clover in rotation with cotton the yields of cotton have shown marked increase year after year. There is apparently no other legume that can be used with as low cost as bur-clover for this purpose. The use of a summer legume crop, such as cowpeas or soybeans, is advisable in good rotations, but where cotton is grown continuously it involves the omission of this crop for an entire growing season. It is much cheaper and much more satisfactory to use bur-clover, which, after it is once established, does not involve much expense for producing seed, nor require the loss of a growing season, as does a summer legume crop. Furthermore, it adds each year a reasonable amount of humus and nitrogen, which in the end gives much more satisfactory results than turning under a large green-manure crop at long intervals. Perhaps no one thing will tend to bring about an increased yield from cotton fields more cheaply than the general use of bur-clover as winter cover and a green-manure crop.

VALUE AS HAY

Under favorable conditions bur-clover will make a dense stand 18 to 24 inches high. From such dense stands of bur-clover, yields of 2 or even 3 tons of hay per acre have been recorded. Unless the stand is very dense, however, bur-clover plants lie close to the ground, and mowing is very difficult. If bur-clover is to be grown for hay, it is preferably sown in mixture with oats or wheat, as with these grain crops the bur-clover plants tend to grow erect. Ordinarily about 5 bushels of bur-clover seed in the bur should be sown to the acre, together with 2 bushels of winter oats or 1½ bushels of wheat. For growing in this manner, however, hairy vetch is preferable to bur-clover, and even crimson clover will ordinarily give larger yields under such conditions than bur-clover. Bur-clover hay is not regarded very highly and is seldom used.

ROTATIONS

Bur-clover may be used as a winter crop in rotation with any cultivated summer crop. Among rotations that have been suggested the following seems desirable:

First year: Cotton; bur-clover sown between the rows September 1.
Second year: Corn or soybeans, followed by volunteer bur-clover.
Third year: Cotton.

A less simple rotation is the following:

First year: Cotton; bur-clover sown between the rows September 1.
Second year: Corn, followed by winter oats.
Third year: Oats, followed by soybeans or cowpeas, preferably in rows. Bur-clover sown in rows September 1. If the soybeans or cowpeas are broadcast, the bur-clover should not be sown before the crop is harvested.
Fourth year: Cotton.

After the bur-clover is well established, subsequent stands can generally be secured in such intertilled summer crops as cotton, corn, soybeans, or sorghums. In broadcast crops, however, such as soybeans, millet, and cowpeas, the shade is so dense that the young bur-clover plants for the most part perish.

The common use by the Chinese of bur-clover as a winter green-manure crop in rotation with rice is also worthy of notice. To a slight extent bur-clover has been used in rotation with rice in Louisiana, and there is every reason to believe that its employment would prove profitable.

The remarkable adaptation of bur-clover for use in rotations is due to the fact that it can be seeded with little or no preparation of the land, if the proper inoculating germs are present in the soil. The only handicap to its general use in this manner, especially where seeding each fall may be necessary, as would be the case with rice, is that it would require a larger and cheaper supply of seed than has yet been available.

GROWING AND HARVESTING SEED

CALIFORNIA BUR-CLOVER

Most of the commercial seed of California bur-clover comes from California. Much of the seed is harvested as an impurity with wheat and other grain crops, from which it is separated at the mills and warehouses handling grain. In recent years, various methods have been used to harvest bur-clover seed directly from pasture lands where there is practically a pure stand and the burs are produced in abundance. The simplest method is sweeping by hand with large stiff brooms. Ordinary mowers, self-rake reapers, combined harvesters, and specially devised suction machines have also been used. When the mower, reaper, or harvester is used, the crop must be cut before all the seeds are ripe, because the burs ripen unevenly and drop readily when ripe. As a consequence, a good deal of green material is harvested with the burs, which necessitates careful drying to prevent damage by heating and sweating. Furthermore, because of the half-prostrate habit of the plants, a large part of the crop is left on the ground.

The power suction machine saves all the seed, but the cost of operation is high. When this machine is used the burs are allowed to become perfectly dry, so that they are easily lifted from the ground by air suction.

When only a small quantity of seed is to be saved, the best method is to sweep by hand. When this method is used the seed is allowed to ripen thoroughly, and the vines are cut with an ordinary mowing machine and raked into windrows. The burs are swept together with large barn brooms and hauled from the field. The burs gathered in this manner are mixed with more or less gravel and other foreign substances, which must be removed before the seed can be satisfactorily hulled or used in the bur. This separation is accomplished by the use of handbarrow screens and an ordinary fanning mill regulated to blow the burs over; or, if running water is handy, a quicker and more satisfactory method is to throw the burs into the water. All heavy substances sink, and the burs and lighter substances are dipped from the stream. To facilitate separation, the channel of the stream should be narrowed in the shape of an open V, which aids in collecting the clean burs. To dip the burs from the water, a large handbarrow with a bottom made of wire netting has been found satisfactory. The burs are spread on canvas to dry, after which they may be successfully hulled with an ordinary clover huller.

A second source of the seed of California bur-clover, often mixed with spotted bur-clover, has been from the burs removed from wool. The quantity of these burs contained in wool is so large that it has been found profitable to save the seed in European wool-cleaning mills. Bur-clover of one or both species is abundant in Argentina and also in Australia, as well as in the Mediterranean countries.

SPOTTED BUR-CLOVER

Practically all the commercial seed of spotted bur-clover is grown in the cotton States. Thus far the seed has been marketed only in the bur, but there is no reason why clean, hulled seed should not be produced in commercial quantities. Hulled seed is much more easily sown, and once the land is inoculated the regular seeding of bur-clover in cotton would replace to a large extent the dependence on volunteer crops.

Raking or sweeping the ripened pods from the ground is the only method used in harvesting spotted bur-clover seed. It is best to allow the burs to become perfectly mature or dry before harvesting. At this time the vines can be raked with a horserake without previous cutting, leaving the shattered burs on the ground. A subsequent raking with a handrake usually will be necessary in order to remove trash that slips between the teeth of the horserake. When the pods are not perfectly dry, care must be exercised in curing, as otherwise the piles will heat, with consequent injury to the seeds. It is probably because of such heating that the commercial seed so often has a low percentage of germination.

Every southern farmer can easily grow his own supply of bur-clover seed at small expense.

YIELD AND WEIGHT OF SEED

Bur-clover seed closely resembles that of alfalfa. Formerly much of it was used to adulterate alfalfa seed, but this practice is now rare, because of the enforcement of pure-seed laws. The two kinds of bur-clover may be distinguished by their seeds (figs. 6 and 7) as well as by their burs.

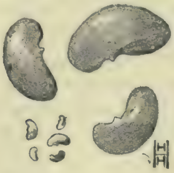

FIGURE 6.—Seeds of spotted bur-clover.

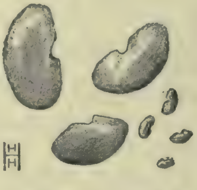

FIGURE 7.—Seeds of California bur-clover.

CALIFORNIA BUR-CLOVER

The average yield of hulled seeds in California is from 300 to 500 pounds per acre. The seeds weigh about 60 pounds to the bushel. One bushel of clean, dry burs weighs 6 to 12 pounds and contains 2 to 4 pounds of seed.

SPOTTED BUR-CLOVER

From a good stand the average yield of burs per acre in the South is about 500 pounds, but yields of 1,200 or even 1,500 pounds per acre are recorded. One bushel of spotted bur-clover seed in the bur weighs from 6 to 14 pounds. One hundred pounds of the clean burs contain 30 pounds of seed. The yield of clean seed per acre is therefore 150 to 360 pounds, or about half the yield of California bur-clover seed secured in California.

INSECT ENEMIES

The only insect that does any serious damage to bur-clover is the clover-seed chalcis fly, which also attacks red clover and alfalfa. This small, wasplike insect lays its eggs through the green pods into the soft seeds, where they hatch and develop, becoming mature insects and emerging by the time the seeds are ripe, or later. The quantity of seed thus destroyed is considerable. In California probably 10 percent of the early maturing seed is destroyed, and as much as 75 percent of the late seed. In the South the loss is probably not so great. No practical way of controlling this insect in bur-clover is known. It does no harm to the herbage.

OBJECTIONS TO BUR-CLOVER

Three objections have been advanced against the use of bur-clover as a forage crop:

(1) The relative unpalatability of the plant. This is most marked in the case of horses and mules, but other animals do not take to it readily at first. However, all farm animals kept on pastures soon acquire a taste for bur-clover and then eat it freely.

(2) The small amount of growth. This objection applies mainly to poor soils and to the northern portions of the Cotton Belt. Even where the growth is very small it is practically always sufficient to prevent the washing of the soil, and this, together with the very insignificant cost of securing a stand each year and the marked ability of the plant to grow in cool weather, makes it valuable, even though the growth is not large.

(3) The burs become entangled in the wool of sheep and thus reduce the value of the wool. This objection applies particularly to California and other regions where bur-clover is abundantly established on range lands. However, the value of the forage far outweighs the small damage done by the burs. On cultivated land the objection scarcely applies, as the difficulty is so easily avoided by removing the sheep from the pasture after the burs are ripe, or else pasturing the bur-clover so heavily that but few burs are formed. It is mainly on account of this objection that a spineless variety of bur-clover is considered desirable on cultivated land.

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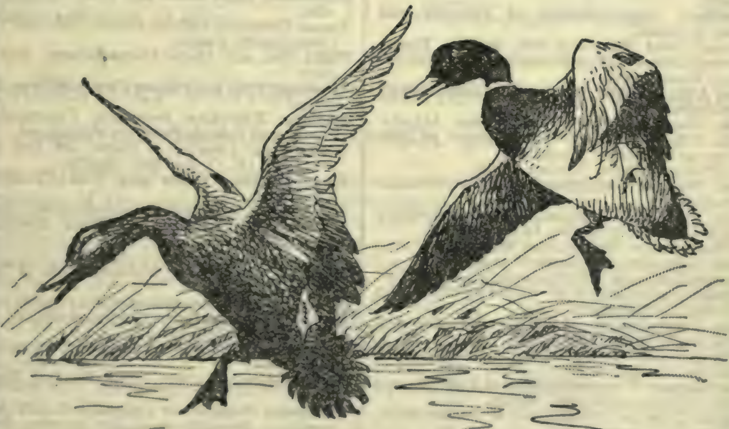
U. S. DEPARTMENT OF AGRICULTURE
FARMERS' BULLETIN No. 1742

GAME LAWS

FOR THE SEASON 1934-35

A Summary of the Provisions of Federal, State, and Provincial Statutes



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THE THIRTY-FIFTH annual summary by the Bureau of Biological Survey of Federal and other game laws and regulations is here presented to inform hunters, farmers, and others interested in wildlife regarding the relation of restrictions on hunting to the future enjoyment of the sport and to aid Federal and State law-enforcement officials in the administration of the Migratory Bird Treaty and Lacey Acts and other laws for the conservation and restoration of game.

The provisions as set forth furnish in ready-reference form a convenient synopsis of the laws. Provisions relating to methods of capture, game refuges, enforcement of laws, disposition of fees and fines, and minor matters are omitted, as also are full texts of Federal and Canadian laws and regulations relating to birds and game. Species not listed under "open seasons" for States and Provinces are protected there at all times.

Persons desiring information regarding further restrictions set by State or Provincial law or regulation on seasons, limits, possession, and other hunting provisions should communicate with the appropriate officials, whose addresses are given below.

The illustration on the title-page is a reproduction of the drawing made by J. N. Darling for use in designing the new Federal migratory-bird hunting stamp. The ducks shown are mallards (*Anas platyrhynchos*).

Washington, D. C. Issued October 1934

OFFICIALS FROM WHOM COPIES OF GAME LAWS MAY BE OBTAINED

Federal laws: Secretary of Agriculture, Washington, D. C.

Alabama: Department of Game and Fisheries, Montgomery.

Alaska: Executive Officer, Alaska Game Commission, Juneau; or Secretary of Agriculture, Washington, D. C.

Arizona: State Game Warden, Phoenix.

Arkansas: Secretary Game and Fish Commission, Little Rock.

California: Executive Officer, Fish and Game Commission, 450 McAllister Street, San Francisco.

Colorado: State Game and Fish Commissioner, Denver.

Connecticut: Superintendent of Fisheries and Game, Hartford.

Delaware: Chief Game and Fish Warden, Dover.

District of Columbia: Superintendent Metropolitan Police, Washington.

Florida: Commissioner, Conservation Department, Tallahassee.

Georgia: Game and Fish Commissioner, Atlanta.

Hawaii: Fish and Game Division, Board of Agriculture and Forestry, Honolulu.

Idaho: Fish and Game Warden, Boise.

Illinois: Director Department of Conservation, Springfield.

Indiana: Director of Game and Fish, Conservation Department, State House, Indianapolis.

Iowa: State Game Warden, Des Moines.

Kansas: State Fish and Game Warden, Pratt.

Kentucky: Game and Fish Commission, Frankfort.

Louisiana: Commissioner of Conservation, Court Building, New Orleans.

Maine: Commissioner of Inland Fisheries and Game, State House, Augusta.

Maryland: State Game Warden, 512 Munsey Building, Baltimore.

Massachusetts: Director Division of Fisheries and Game, 20 Somerset Street, Boston.

Michigan: Director Department of Conservation, Lansing.

Minnesota: Game and Fish Commissioner, Department of Conservation, St. Paul.

Mississippi: Director of Conservation, State Game and Fish Commission, Jackson.

Missouri: Game and Fish Commissioner, Jefferson City.

Montana: State Fish and Game Warden, Helena.

Nebraska: State Game Warden, Lincoln.

Nevada: Secretary of State Fish and Game Commission, Reno.

New Hampshire: Fish and Game Commissioner, Concord.

New Jersey: Secretary of Board of Fish and Game Commissioners, Trenton.

New Mexico: State Game and Fish Warden, Santa Fe.

New York: Director of Fisheries and Game, Conservation Department, Albany.

North Carolina: Director, Department of Conservation and Development, Raleigh.

North Dakota: Game and Fish Commissioner, Bismarck.

Ohio: Commissioner of Conservation, Columbus.

Oklahoma: State Fish and Game Warden, Oklahoma City.

Oregon: State Game Commission, 616 Oregon Building, Portland.

Pennsylvania: Executive Secretary Board of Game Commissioners, Harrisburg.

Rhode Island: Chairman Commissioners of Birds, Providence.

South Carolina: Chief Game Warden, Columbia.

South Dakota: Director Division of Game and Fish, Department of Agriculture, Pierre.

Tennessee: State Game and Fish Warden, Nashville.

Texas: Executive Officer, Game, Fish, and Oyster Commission, Austin.

Utah: Fish and Game Commissioner, Salt Lake City.

Vermont: Fish and Game Commissioner, Montpelier.

Virginia: Executive Secretary, Commission of Game and Inland Fisheries, Richmond.

Washington: Director of Game, 404 Bell Street, Terminal (P. O. Box 384), Seattle.

West Virginia: Game and Fish Commission, Charleston.

Wisconsin: Conservation Commissioner, Madison.

Wyoming: State Game and Fish Commission, Cheyenne.

Canada: Commissioner, National Parks of Canada, Ottawa.

Alberta: Game Commissioner, Edmonton.

British Columbia: Game Commissioner, 411 Dunsmuir Street, Vancouver.

Manitoba: Director of Game and Fisheries, Winnipeg.

New Brunswick: Chief Game Warden, Fredericton.

Northwest Territories: Dominion Lands Administration, Department of the Interior, Ottawa, Ontario.

Nova Scotia: Minister of Lands and Forests, Halifax.

Ontario: Department of Game and Fisheries, Toronto.

Prince Edward Island: Game Inspector, Provincial Treasury Department, Charlottetown.

Quebec: General Superintendent of Fisheries and Game, Quebec.

Saskatchewan: Game Commissioner, Department of Natural Resources, Regina.

Yukon: Territorial Secretary, Dawson.

Newfoundland: Secretary Game and Inland Fisheries Board, St. Johns.

Mexico: Secretaria de Agricultura y Fomento, Director Forestal y de Caza y Pesca, San Jacinto, D. F., Mexico.

GAME LAWS FOR THE SEASON 1934–35

A SUMMARY OF FEDERAL, STATE, AND PROVINCIAL STATUTES

By H. P. Sheldon, *in charge*, and Frank G. Grimes, *assistant; Division of Public Relations, Bureau of Biological Survey*

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MIGRATORY WATERFOWL RESTORATION PROGRAM

RESTRICTIONS ON THE ANNUAL KILL BY HUNTERS

FOR THE PAST 5 YEARS the Bureau of Biological Survey, through the medium of the annual game-law bulletins and other publications, has called attention to the steady diminution in the numbers of migratory waterfowl, especially some of the more highly prized species that nest in the Prairie Provinces of Canada and in the North Central States, including eiders, canvasbacks, redheads, teals, scaups, ringnecks, shovelers, and gadwalls. Sportsmen have been urged from time to time during this period to exercise extreme moderation in their annual kill, in order that satisfactory breeding stocks may return each year to the nesting grounds. Seasons and bag limits have been reduced and other restrictive measures adopted with the hope of offsetting the losses caused by drought, by drainage and other agricultural operations, and by overshooting. Despite these measures, it is apparent from intensive studies and observations made during the 1934 nesting season that the waterfowl supply this year will be below that of 1933. The drought of 1934 has been the most serious and widespread in the history of the country; thousands of lakes, ponds, and sloughs throughout the great central flyway of the birds have been obliterated; and as a result even greater concentrations of waterfowl may be expected this year on the coastal areas that have escaped the ravages of drought. Data gathered by the Biological Survey during 1934 furnish indisputable evidence that all species of wild ducks are facing the most serious crisis in the history of wildfowling. Sportsmen are again urged, therefore, to be generous in their response to the Bureau's plea for moderation in shooting.

RESTORING REFUGE AREAS

The Biological Survey has evolved and is now developing an ambitious program for the restoration of areas that formerly were the favorite haunts of wildfowl. A major project in this program involves the expenditure of $8,500,000, allocated from various emergency funds released for the purpose by Federal agencies. The bulk of these funds will be used to restore the waterfowl nesting areas that are in this country. The program also involves the impounding of water—a project so expensive that it can be undertaken only when ample funds are made available. A reasonable percentage of the funds provided will be used to acquire feeding and resting refuges along the Mississippi flyway, this system to be later tremendously augmented by refuges to be acquired and put into production from the proceeds of the Federal migratory-waterfowl hunting-stamp fees. Expert hydraulic engineers, naturalists acquainted with facts on the geographic distribution and migratory habits of birds, and biologists conversant with the food habits and food requirements of the various species must pass upon every site proposed before it is made into a refuge. Only thus can sportsmen be assured that both they and the ducks will get a full dollar's value for every dollar expended.

Up to October 1, 1934, 12 major duck-nesting refuges had been planned in the great northern breeding grounds, embracing 300,000 acres of water and marshlands. Construction and land acquisition on these projects are well under way, and many of the areas will be producing wild fowl under sanctuary conditions during the next nesting season. In addition, negotiations have been begun for the acquisition of at least a dozen more resting and feeding refuges down the Mississippi flyway, a number that will probably be doubled before the funds are exhausted. These do not include a number of key refuges elsewhere, sometimes referred to as superrefuges in the waterfowl program. Embraced in these superrefuges are the Mattamuskeet Lake, of approximately 50,000 acres, in North Carolina; another of approximately 45,000 acres in the White River country in Arkansas; and the great P Ranch, of about 65,000 acres, in the Donner and Blitzen Valley in Oregon, designed to lead ultimately to the restoration of Malheur Lake.

All refuges will be placed under expert supervision that will restore breeding grounds and nesting cover, develop waterfowl foods, and make them at all times attractive and serviceable to waterfowl of all species. In most cases the upland game will benefit incidentally by the establishment of Federal refuges for migrant birds.

This is the beginning of a gigantic restoration program. With the continued support of the public in the purchasing of migratory-waterfowl hunting stamps, refuges at almost every 100-mile interval down the most important flyways can be established. These will not interfere in any way with the recreation of local sportsmen, but will ultimately insure the continuance of the sport of wildfowling.

The acquisition of areas under the Migratory Bird Conservation Act has been greatly curtailed for lack of the requisite funds. During the past year 485 acres were conveyed to the United States for use as refuges. Two refuges aggegating 136,624 acres were established by Executive order—the Killcohook Refuge on the Delaware River, in Salem County, N. J., and New Castle County, Del., and the Railroad Valley Refuge in Nye County, Nev. The latter refuge is being improved by the development and impounding of water with funds made available under the National Industrial Recovery Act.

Under the Emergency Conservation Works program, Civilian Conservation Corps camps are now established on three Federal refuges administered by the Biological Survey. The program of work, much of which has been completed, includes the construction of telephone lines, truck trails, firebreaks, necessary buildings, and of dikes and dams for the creation of ponds and for water conservation, and the planting of wildlife food. Similar improvements are being made under the Public Works and the emergency refuge development programs on several of the refuges now administered by the Survey.

REVIEW OF LEGISLATION OF 1934

FEDERAL LEGISLATION

MIGRATORY BIRD HUNTING STAMP ACT

Under an act approved by the President on March 16, 1934 (Pub. No. 124, 73d Cong.), all persons over 16 years of age hunting migratory waterfowl (wild ducks, wild geese, and brant) are required to purchase from a postmaster a Federal migratory-bird hunting stamp, costing $1, which must be adhesively affixed to their State hunting license. If a State license is not required, the stamp must be adhesively affixed to a certificate furnished by the postmaster. The stamp is not required for the taking of migratory waterfowl by Federal or State institutions or official agencies; for propagation purposes; or, under such restrictions as the Secretary of Agriculture may by regulation prescribe, by the resident owner, tenant, or share cropper for the killing of waterfowl injuring crops or other property. The moneys derived from the sale of these stamps are set aside as a special fund to be administered by the Secretary of Agriculture, 90 percent to be available for the location, investigation, acquisition, administration, and development of suitable areas for inviolate migratory-bird sanctuaries; the remaining 10 percent to be available for administrative expenses under the Migratory Bird Hunting Stamp and the Migratory Bird Conservation Acts, including reimbursement to the Post Office Department for the printing, engraving, and issuance of the stamps, and for administrative expenses under the Migratory Bird Treaty and Conservation Acts, and other acts to carry into effect treaties for the protection of migratory birds.

WILDLIFE COORDINATION ACT

An act (Pub. No. 121, 73d Cong.) approved by the President on March 10, 1934, authorizes the Secretary of Agriculture and the Secretary of Commerce to provide expert assistance to, and to cooperate with, Federal, State, and other agencies, in rearing, stocking, and increasing the supply of game and fur-bearing animals and fish; in combating diseases; and in developing a Nation-wide program of wildlife conservation and rehabilitation. No funds are provided for the carrying into effect of the act, but its general purport is to require that the Bureaus of Fisheries and Biological Survey shall be given an opportunity, whenever the Federal Government, through reclamation or otherwise, impounds water for any use, to make such use of the impounded waters for fish-culture stations and migratory-bird resting and nesting areas as are not inconsistent with the primary use of the impounded waters or the constitutional rights of the States. Under this act it is hoped that migratory-bird refuges may be established on a number of other Federal projects.

ACT AUTHORIZING REFUGES ON NATIONAL FORESTS

An act approved March 10, 1934 (Pub. No. 120, 73d Cong.), authorizes the President, upon recommendation of the Secretary of Agriculture and the Secretary of Commerce, and with the approval of the legislatures of the several States in which national forests are situated, to establish by proclamation certain areas within such forests as fish and game sanctuaries or refuges.

MIGRATORY BIRD TREATY ACT REGULATIONS

Amendments to the regulations under the Migratory Bird Treaty Act, approved and proclaimed by the President on August 20, 1934, provide radical changes in the seasons on migratory game birds and on methods of hunting them. For the first time since the passage of the Migratory Bird Treaty Act, approval was given to a modification of the rest-day or lay-day plan of stating the open seasons. Though rest-days are admittedly not a conservation measure, it was considered that cutting the number of shooting days 50 percent warranted acceding to the numerous requests from States that this year the system be given a trial. Under this plan the sportsmen are afforded the maximum shooting opportunities consistent with an earnest intention to maintain adequate breeding stocks to insure the perpetuation of the game birds and the sport of wildfowling. This innovation, and the other amendments, both those liberalizing hunting privileges and those increasing the restrictions, have been received by the public with varying degrees of approval and disapproval.

The new regulations cut the shooting days from 60 to 30, each State having been permitted to select the weekly shooting days considered most desirable to meet local conditions, climatic and otherwise, the season selected to be spread over a period not to exceed approximately 3½ months. In accordance with this plan, 2 States selected a solid season of 1 month; 8 selected 5 days a week for 6 weeks; 30 selected 3 days a week for 10 weeks, and 5, 15 weeks of 2 days each. The selected seasons were incorporated in the amended regulations. Some of the States selected Sunday as a shooting day, notwithstanding conflict with other State laws. The shooting days of each week, and the spread of the seasons, will be found under the appropriate headings for each State.

Amendments relative to hunting methods prohibit the use of bait in the taking by shooting or otherwise of mourning doves; and prohibit the taking of waterfowl (wild ducks, wild geese, and brant) on baited areas except under seasonal permits issued by the Biological Survey. This amendment provides that no waterfowl except crippled birds that are not otherwise retrievable may be shot while resting on land or water; and that no waterfowl may be shot on baited premises after 3 p. m. This regulation also requires the submission of reports that will provide data upon which to base future regulations on baiting.

The amendment pertaining to bag limits reduces the daily bag to 5 of any one, or 5 in the aggregate, of eider ducks, canvasbacks, redheads, scaups, ringnecks, teals, shovelers, and gadwalls, which have become so depleted as to require this special protection, and makes the limit 12 on other ducks.

HUNTING AND FISHING REGULATIONS FOR NATIONAL FORESTS

On March 29, 1934, the Secretary of Agriculture adopted a regulation providing that when he shall determine that the regulation of hunting or fishing on any national forest is necessary, he shall designate such forest, establish hunting and fishing seasons, fix bag and creel limits, determine the fees to be charged for hunting and fishing permits, designate the official to whom application for permits shall be made, and prescribe the terms and conditions under which hunting and fishing shall be conducted.

STATE LEGISLATION

Regular legislative sessions were held during the past year in 9 States, at which changes of minor importance were made in the game laws. In several other States changes were effected by commission orders or regulations.

Louisiana and New Jersey adopted provisions making the State laws with respect to migratory game birds conform to changes in the Federal regulations under the Migratory Bird Treaty Act.

Emphasizing the State law, the Governor of Minnesota, by proclamation, prohibited the baiting or feeding of migratory waterfowl, even though Federal permit may have been issued.

In North Dakota, Mondays and Tuesdays were declared rest days for the hunting of pheasants.

Tennessee prohibited nonresidents in two counties from hunting except upon land owned by them.

Wisconsin adopted a provision, by proclamation of the Governor, prohibiting the shooting of waterfowl in certain counties after 4 p. m.

SEASONS

BIG GAME

Deer.—Colorado extended the deer season 3 days, to close October 18 instead of October 15. Idaho shortened the season 6 days in 1 county closing October 24 instead of October 30, while Louisiana shortened the season 15 days throughout the State, changing it from November 15–February 15 to November 1–January 15. Mississippi closed the season throughout the State except in 22 counties, in which a uniform season of 1 month (Dec. 15–Jan. 15) is prescribed. Montana opened the season on does in 7 counties. North Dakota closed the season throughout the State. Texas closed the season in 1 county, while West Virginia closed it throughout the State except in 7 counties, where a 6-day season, November 12 to 17, was prescribed. In Wisconsin the season was opened for 7 days, November 24 to 30, in 22 counties, and in 2 counties the season November 24 to 28 was prescribed for hunting with bow and arrow.

Elk.—Oregon extended the elk season in 4 counties, making it November 5 to 11 instead of October 23 to 25. Washington made the season in 6 counties November 1 to 11, and Wyoming made certain adjustments in county seasons.

Moose.—In Wyoming the moose season in 2 counties was extended 15 days, closing November 30 instead of November 15; in 1 county it was extended from October 1–November 5 to October 1–November 30; while in still another county the season was shortened, opening October 15 instead of October 1, and closing October 31 instead of November 5.

Antelope.—New Mexico continued the open season on antelope in certain areas in 2 counties, October 1 to 5, special permits being required in addition to the regular hunting license. In 8 counties in Wyoming an open season, September 5–October 10, was prescribed.

Bear.—Alabama shortened the bear season, opening 4 months later—September 1 instead of May 1. Louisiana shortened the season from November 15–February

15 to November 1–January 1. New Hampshire and Pennsylvania closed the season altogether, while New Mexico extended the season, to open October 1 instead of October 25. New York extended the season in 6 counties in the Adirondack section, closing December 31 instead of November 15. West Virginia opened the season throughout the State, November 18 to December 31, while Wisconsin opened it in 14 counties, November 24 to 30, the season in both States having heretofore been closed.

SMALL GAME

Rabbits and squirrels.—A number of local changes were made in the rabbit and squirrel seasons in California, Iowa, Louisiana, Massachusetts, Mississippi, Nebraska, New York, Tennessee, Virginia, West Virginia, and Wisconsin, the general trend being toward curtailment of the seasons.

GAME BIRDS

Quail.—Kentucky changed the quail season from November 15–December 31 to November 24–January 9. Louisiana lengthened it 15 days, opening November 1 instead of November 15. New Hampshire closed the season in the entire State, Missouri in 1 county, and New York in 2 additional counties, leaving an open season in only 3. Oregon extended the season on mountain and valley quail, to open October 1 instead of October 15; opened 2 counties to bobwhite-quail hunting; extended the season on Hungarian partridges in 1 county and opened it in another October 15 to 31. Texas closed the season in 1 county. Wisconsin opened the quail season in 8 additional counties September 29 to October 2, besides opening the season on Hungarian partridges for 4 days in 3 additional counties.

Wild turkey.—Kentucky closed the entire State to wild-turkey hunting, as did also West Virginia except in 13 counties, where a single month's shooting was allowed beginning October 17. Minnesota closed 31 counties to turkey shooting, and shortened the season elsewhere in the State by making it April 1–20 instead of November 20–January 31. Alabama also shortened the season, opening December 1 instead of November 1. Pennsylvania added 2 counties to the closed list, and Texas added 5, but extended the season in 3 from November 16–December 31 to November 1–April 30.

Pheasant.—California opened the season on pheasants in 1 district. Idaho shortened the season 5 days in certain counties, and Mississippi closed the season throughout the State. North Dakota closed all but 22 counties, in 5 of which the season was made October 20 to November 2, and in 17, October 20 to 26. Oregon extended the season to 4 days instead of 2 in 1 county, and opened 6 counties that formerly were closed. South Dakota provided a uniform season of October 21 to November 4 east of the Missouri River instead of the former split seasons of 2 weeks each; closed the season in the hill portions of 4 counties; and prescribed a 2-day season west of the Missouri River except in 1 county where it was made 5 days, and in 2 counties where the season October 21 to November 4 was prescribed. Texas closed the season in 5 counties. Local seasons were prescribed in a number of counties in Wisconsin.

Grouse and prairie chicken.—Kentucky closed the season on ruffed grouse, and New Mexico closed on both grouse and prairie chicken except in 3 counties, where the 4-day season September 21–25 was prescribed. North Dakota shortened the season on prairie chicken and sharp-tailed grouse from September 16–October 16 to September 22–October 1, and in 3 counties prescribed a 4-day season on ruffed grouse. In South Dakota the season on grouse remains closed except west of the Missouri River, where it is open from September 27 to 30. In West Virginia the season on ruffed grouse was extended from October 16–November 30 to October 17–December 15. In Wisconsin local seasons were prescribed on both species.

Woodcock.—Iowa closed the season on woodcock, rails, and gallinules, as did Wisconsin on woodcock except in 34 counties, where hunting from September 29 to October 15 is allowed.

Dove.—Tennessee shortened the dove season in 1 county and closed it in 1.

LICENSES

In Florida a provision of the State law exempting residents of Madison and Suwanee Counties from procuring a hunting license was declared unconstitutional. Iowa increased the hunting-license fee for residents over 16 years of age from $1 to $2, imposed a fee of $1 on residents under 16, and authorized a combined $2.50

hunting and fishing license for residents. In Massachusetts citizens of the State over 70 years of age were exempted from the hunting-license requirements, and in Tennessee residents of six counties were also exempted. Texas rescinded the provision for a 5-day nonresident license. Virginia provided for a special license for the erection of ducking blinds in five counties, fee $5.10, and in five counties reduced the fee for a special elk permit to $1, both for residents and nonresidents.

BAG LIMITS

Tennessee reduced the bag limit on deer from 2 to 1 a season. In Pennsylvania the bag limit on rabbits was reduced from 5 a day, 30 a season, to 4 a day, 24 a season.

PROVINCIAL LEGISLATION

BIG GAME

In British Columbia the season on male deer in the western district was shortened, closing November 30 instead of December 15; in the same district the season on does was opened December 1 to 15. In Manitoba an additional season was prescribed on caribou, moose, and deer south of the fifty-third parallel, thus providing the split season September 25 to October 15, and November 15 to December 5. In New Brunswick the season on deer was extended 15 days, opening September 15 instead of October 1, except on Grand Manan Group, Campobello, and Deer Island.

GAME BIRDS

New Brunswick closed the season on partridge and Alberta extended it on Hungarian partridge to close December 15 instead of November 30. Manitoba extended the season on this bird from 2 to 5 days, as well as on prairie chicken and ruffed grouse, and from 2 to 20 days on ptarmigan. In Saskatchewan the season on Hungarian partridge was extended 1 month, and on grouse 16 days.

BAG LIMITS

In Manitoba the daily bag on ducks during October and November was reduced from 30 to 25, and the season limit from 150 to 100, while a possession limit of 40 was prescribed. Saskatchewan increased the daily bag on Hungarian partridge from 10 to 15, and on coots from 25 to 30.

FEDERAL LAWS RELATING TO MIGRATORY BIRDS

The full text of the Migratory Bird Treaty Act and the regulations thereunder, the Migratory Bird Hunting Stamp Act, and other Federal laws and regulations relating to wildlife protection and conservation is published in a Service and Regulatory Announcement of the Bureau of Biological Survey (B. S. No. 79), copies of which can be obtained from the Bureau upon request. The full text of regulation 3, however, concerning the means by which migratory game birds may be taken is quoted in the next paragraph, and a résumé of other salient provisions of the regulations follow. The open-season and bag-limit provisions are omitted for the reason that they are included in the State summaries (pp. 8 to 37).

HUNTING METHODS

The migratory game birds specified in regulation no. 4 may be taken during the open season with a gun only, not larger than no. 10 gage, fired from the shoulder, except as specifically permitted by regulations nos. 7, 8, 9, and 10; they may be taken during the open season from land and water, with the aid of a dog, the use of decoys, and from a blind or floating device, except that in the taking of wild ducks not more than 25 live duck decoys may be shot over, and in the taking of wild geese in California the use of live goose decoys is not permitted; but nothing herein shall be deemed to permit the use of an automobile, airplane, power boat, sailboat, any boat under sail, any floating device towed by power boat or sailboat, or any sinkbox (battery), except that sinkboxes (batteries) may be used in the taking of migratory waterfowl in coastal sounds and bays (including Back Bay, Princess Anne County, State of Virginia) and other coastal waters; and nothing herein shall be deemed to permit the use of an airplane, or a power boat, sailboat, or other floating device for the purpose of concentrating, driving, rallying, or stirring up migratory waterfowl; and mourning doves shall not be shot or otherwise taken by means of bait.

Waterfowl (except those taken pursuant to regulation 8 of these regulations) shall not be shot or otherwise taken on any baited premises except under seasonal permits issued without charge by the Chief of the Bureau of Biological Survey of the Department of Agriculture: *Provided, however*, That such permits will be issued only upon the conditions and requirements hereinafter specified, which will be stated in every permit, and when said Chief shall, after investigation, ascertain and determine that any bait on any premises is or will be effective to subsist such waterfowl under stress of absence, failure, or diminution of the normal or natural food supply of waterfowl in that particular locality or section, or to concentrate such waterfowl under conditions conducive to safeguarding them from greater destruction that would otherwise occur, and when it shall additionally appear that such shooting will more nearly equalize waterfowl-hunting privileges in the various localities or sections within the jurisdiction of the United States and will not contribute to disproportioned destruction of such waterfowl in any such particular locality or section. Forms upon which to apply for permits will be furnished by the Chief of said Bureau upon request. Permits will be issued to and in the name of the person owning, leasing, or otherwise controlling or occupying any premises. Any permit may be revoked by the Secretary when he determines, after investigation, that baiting as employed on the premises constitutes a disproportioned agency in the killing of migratory waterfowl, or upon proof that the permittee has willfully violated or failed to comply with, or has suffered others hunting on the premises to violate or fail to comply with, any of the following conditions and requirements: No waterfowl, except crippled birds not otherwise retrievable, shall be shot while resting on water or land on any premises. No waterfowl shall be shot on any premises after 3 o'clock p. m. Every permittee shall keep an accurate record of the number of persons shooting during each season on the premises covered by the permit; the species and the number of each species and the total number of all species of waterfowl killed on said premises during each season; and the number of blinds, the number of gunners shooting from each blind each day, the number of birds killed each day by each gunner at each blind, and kinds of feed and interval of feeding; and shall send to the Chief of said Bureau, within 1 month after the close of the open season, a report containing the aforesaid information. No permit issued shall be construed to be effective to permit shooting of waterfowl on any premises in violation of State law or regulation.

SALE

The Federal law prohibits the sale of all migratory birds throughout the United States except birds taken for scientific or propagating purposes and waterfowl raised on farms or preserves under permit from the Secretary of Agriculture. Feathers of wild ducks and wild geese lawfully killed, and of such birds seized and condemned by Federal or State authorities, may be purchased and sold for use in the manufacture of fishing flies, pillows, and mattresses, but not for millinery or ornamental purposes.

ALASKAN EXCEPTIONS

In Alaska, Eskimos and Indians may take for the use of themselves and their immediate families, in any manner and at any time, and possess and transport auks, auklets, guillemots, murres, and puffins and their eggs for food and their skins for clothing.

PERMITS FOR PROPAGATION AND OTHER PURPOSES

Under appropriate permit from the Secretary of Agriculture, and when allowed by State law, migratory waterfowl may be captured for propagating purposes, and waterfowl bred in captivity may be killed and the carcasses sold and used for food purposes. Waterfowl captured and bred in captivity may also be sold alive for breeding and exhibition purposes to the holders of permits. Under appropriate permit all species of migratory birds (except whooping cranes, trumpeter swans, and Eskimo curlew) may be taken for scientific purposes, and all species may be taken for banding. The Secretary of Agriculture may also issue orders permitting the killing of migratory birds to prevent serious injury to agriculture or other interests.

FURTHER RESTRICTIONS BY STATES

The States may shorten the open seasons fixed by Federal regulations on migratory birds, reduce the bag limits, prohibit export, restrict the period during which migratory birds may be possessed in close season, or make other laws or regulations to give further protection to such birds, but may not lengthen the open season, increase the bag limit, permit sale, or otherwise lessen the protection afforded by Federal law.

SUMMARY OF LAWS RELATING TO SEASONS, LICENSES, LIMITS, POSSESSION, TRANSPORTATION, AND SALE

GENERAL INFORMATION

Persons are advised to obtain from State game commissioners the full text of game laws in States where hunting is contemplated. (See list on p. II.) They should also obtain information from the Bureau of Biological Survey or State game departments regarding the existence of Federal and State game and bird refuges in areas in which they contemplate hunting, as the location of refuges and the restrictions regarding hunting thereon are not included in this bulletin.

OPEN-SEASON DATES

The dates of open seasons for migratory game birds shown under the various States and Provinces are the times when these birds may be hunted without violating either State or Provinical laws or Federal or Canadian regulations.

In stating the open season the plan has been followed of including the first and last days thereof. The difficulty of attaining absolute accuracy in a statement of the seasons is great, but summaries have been submitted to the proper State or Provincial game officials for correction and approval, and the dates as stated are believed to be free from material errors.

REST DAYS

Under the laws of some States certain days of the week constitute rest days, or close seasons during the period when hunting is permitted. Persons contemplating shooting trips should inform themselves of the provisions of State law in this respect.

STATE LAWS

ALABAMA

Open seasons:	*Dates inclusive*
Deer (male)	Nov. 1–Dec. 31.
Bear	Sept. 1–Feb. 28.
Squirrel (see exception)	Oct. 1–Dec. 31.
Exception: In Baldwin, Butler, Choctaw, Clarke, Conecuh, Covington, Crenshaw, Dallas, Escambia, Lowndes, Mobile, Monroe, Montgomery, Washington, and Wilcox Counties	Nov. 1–Jan. 31.
Quail (partridge)	Nov. 20–Feb. 20.
Wild turkey gobbler	Dec. 1–Dec. 31. Mar. 1–Apr. 10.
Ruffed grouse, introduced pheasant	Nov. 15–Dec. 15.
Dove (see exception)	Sept. 1–Sept. 30. Nov. 20–Jan. 31.
Exception: In Mobile, Baldwin, and Washington Counties	Nov. 1–Jan. 31.
Woodcock	Dec. 1–Dec. 31.
Duck (except wood duck, ruddy duck, and bufflehead), goose (except Ross' goose), brant, coot (mud hen), Wilson's snipe or jacksnipe, Thursdays, Fridays, Saturdays	Nov. 8–Jan. 12.
Rail and gallinule, other than coot	Sept. 1–Nov. 30.

Hunting licenses: Nonresident or alien, $25. Nonresident 1-week trip license, $5. Resident—State, $3; county, $1. Issued by probate judges and game commissioner.

Bag and possession limits: 1 buck a day or in possession, 5 a season; 1 turkey gobbler a day or in possession, 10 a season; 10 squirrels, 15 quail a day or in possession; 25 of each other species of upland game birds a day; 12 ducks a day, but not more than 5 of any one, or in the aggregate, of the following species—canvasback, redhead, scaup, ringneck, teal, shoveler, and gadwall; 4 geese, including brant, a day; 25 sora, 25 coot, 25 in the aggregate of all rails and gallinules except sora and coot, but not more than 15 of any one species of rails and gallinules, 20 Wilson's snipe, 4 woodcock, 18 doves a day. Not more than 1 day's bag limit of game birds may be possessed at one time. Possession of migratory game birds permitted during first 10 days of close season; other game during first 5 days. Game taken outside of State and legally exported may be possessed in like manner as game taken in State.

Interstate transportation: Export of all protected game prohibited, except nonresident licensee may take with him, openly, game he has lawfully killed, but not more than 2 days' limit of migratory game birds may be exported in 1 calendar week.

Baiting: Doves may not be shot or otherwise taken by means of bait, nor may ducks, geese, or brant be taken on baited premises except under seasonal permits issued by the Biological Survey.

ALASKA

Open seasons:[1]	*Dates inclusive*
Bull moose (except yearlings and calves)	Sept. 1–Dec. 31.
Caribou, south of Yukon River	Aug. 20–Dec. 31.
North of Yukon River	No close season.
Deer (male, with horns not less than 3 inches above skull), east of longitude 138° (southeastern Alaska)	Aug. 20–Nov. 15.
In rest of Territory	No open season.
Mountain sheep (rams), mountain goats (except kids)	Aug. 20–Dec. 31.
Bear (large brown and grizzly)	Sept. 1–June 20.[2]
Black bear, polar bear (fur animals)	No close season.
Grouse, ptarmigan	Sept. 1–Feb. 28.
Duck (except ruddy duck and bufflehead), goose (except Ross's goose), brant, Wilson's snipe or jacksnipe, Saturdays, Sundays, Mondays	Sept. 1–Nov. 5.
Rails, gallinules	Sept. 1–Nov. 30.

Hunting licenses: Nonresident citizen—general, $50; small game, $10; licenses issued by commissioners, wardens, and special agents. Resident, $2 (trapping license required for taking black bears, which are fur animals under the law; not required of native-born Indians, Eskimos, or half-breeds who have not exercised the right of franchise or severed their tribal relations). Alien, $100 (special license required to hunt or possess firearms); issued by commission.

Guide $10 (issued only to resident citizens or resident native Indian or Eskimo); issued by commission.

Shipping licenses: Resident (export for mounting and return), $1 for each trophy; resident removing from Territory, $1 for each trophy; if otherwise, $5 for each animal, $1 for each bird. Issued by commission or collector of customs.

Bag and possession limits: Caribou, nonresident 2, resident 5, a season (except on Alaska Peninsula, resident 2, nonresident 1); mountain sheep, nonresident 2 (on Kenai Peninsula, 1), resident 3 a season, of which not more than 2 may be taken south of Arctic Circle; 1 moose, 3 deer, 2 mountain goats a season or in possession; 2 in all of large brown and grizzly bears a season or in possession (nonresident); no limit for resident except 2 only in certain areas where a season is prescribed for residents, and in southeastern Alaska. Game animals legally taken during open season may be possessed and transported within Territory by any person at any time. Fifteen grouse, 25 ptarmigan, but not more than 25 in all of grouse and ptarmigan a day; 12 ducks a day, but not more than 5 of any one, or in the aggregate, of the following species—eiders, canvasback, redhead, scaup, ringneck, teal, shoveler, and gadwall; 4 geese, including brant, 20 Wilson's snipe a day. Migratory game birds legally taken may be possessed during open season and 10 days thereafter, but not more than 50 in all of such birds may be possessed at one time, of which not more than 2 days' limit may be ducks, and geese, including brant. Game animals, grouse, ptarmigan hides, heads, and feet of game animals or articles made therefrom and skins and feathers of game birds legally taken during open season may be possessed and transported at any time within the Territory, and shed antlers of deer, moose, or caribou may be possessed and transported within or out of the Territory at any time without a license.

Interstate transportation: Nonresident citizen or nonresident alien licensee may export 1 moose, 3 deer, 2 caribou (1 from Alaska Peninsula), 2 mountain sheep (1 from Kenai Peninsula), 2 mountain goats, and 2 in all of large brown and grizzly bears killed by himself under license coupon and affidavit that he has not violated the game laws; that big-game animal or part thereof he desires to ship has not been purchased or sold and is not shipped for purpose of being sold; that he lawfully killed the animal and is owner of part thereof that he desires to ship, and if shipment contains caribou or parts thereof, whether animal was killed on Alaska Peninsula.

A nonresident may possess and transport at any time within or out of Territory skins and feathers of game birds and articles manufactured from hides or hoofs of moose, caribou, deer, or goats legally taken.

Residents may export for mounting and return in any one year, but not for sale, heads or trophies of game animal legally acquired under shipping license (fee, $1 for each trophy).

A resident who is removing his residence from Territory may export trophies of game animals legally acquired by him under shipping license (fee, $1 for each trophy).

All shipments must be marked with names and addresses of consignor and consignee and number of each kind of game contained therein.

Baiting: Ducks, geese, and brant may not be taken on any baited premises except under seasonal permits issued by the Biological Survey.

ARIZONA

Open seasons:	*Dates inclusive*
Deer (male with pronged horn), bear (adult), wild turkey (see exception)	Oct. 16–Nov. 15.
Exception: Black-tailed or mule deer, bear, turkey, south of Gila River	No open season.
Squirrel (except Kaibab squirrel in State, and Chiricahua and Arizona tree squirrels south of Gila River and Salt River base meridian, no open season)	Oct. 16–Nov 15.
Quail (Gambel's scaled) (see exception)	Nov. 1–Dec. 31.
Exception: In Apache and Navajo Counties	No open season.
White-winged dove	July 15–Aug. 31.
Mourning dove	Sept. 1–Dec. 15.
Band-tailed pigeon	Dec. 1–Dec. 15.
Duck (except wood duck, ruddy duck, and bufflehead), goose (except Ross's), brant, coot, Wilson's snipe or jacksnipe, Saturdays, Sundays	Oct. 6–Jan. 13.

Hunting licenses: Nonresident—game and fish, $25; small game and fish, $10; fishing, $3. Resident game and fish, $2.50. Alien—game and fish, $75; small game and fish, $30. Special license, alien applicant for citizenship, small game and fish, $10. Guide, $10.

Bag and possession limits: 1 deer, 1 bear, 6 squirrels, 2 turkeys a season; 15 quail a day or in possession; 12 ducks a day or in possession, but not more than 5 a day of any one or in the aggregate, of the following species—canvasback, redhead, scaup, ringneck, teal, shoveler, and gadwall—10 in possession; 2 brant or geese, a day or in possession; 15 in all of Wilson's snipe and coots a day or in possession; 15 white-winged doves, 15 mourning doves a day. One male deer, 2 wild turkeys, or 1 day's bag limit of other game lawfully taken may be possessed for 10 days after close of season. Game taken outside of State and legally exported may be possessed in like manner as game taken in State.

Interstate transportation: Nonresident licensee may ship 1 day's bag limit of game a week under permit attached to license, and may procure additional license for additional shipment.

Baiting: Doves may not be shot or otherwise taken by means of bait, nor may ducks, geese, or brant be taken on baited premises except under seasonal permits issued by the Biological Survey.

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[1] *Alaska:* Certain areas on which all hunting, or the hunting of certain species, is prohibited, may be ascertained by consulting Alaska Game Commission Circular No. 11 and supplements thereto, Laws and Regulations Relating to Game, Land Fur-Bearing Animals and Birds in Alaska, published by the Department of Agriculture, or by communicating with the Alaska Game Commission, Juneau, or the Department of Agriculture, Washington, D. C.

[2] Season on large brown and grizzly bears applies throughout Territory to nonresidents, and to residents in coastal regions described in the circular referred to in footnote 1.

ARKANSAS

Open seasons:	*Dates inclusive*
Deer (male, with horns plainly visible above skull), bear, turkey gobbler (gobbler also Apr. 1–Apr. 30)	Nov. 12–Nov. 17, Dec. 20–Jan. 1.
Squirrel	May 15–June 15, Oct. 1–Jan. 1.
Pheasant, prairie chicken	Dec. 1–Dec. 15.
Quail or partridge (bobwhite)	Dec. 1–Jan. 31.
Dove	Sept. 1–Dec. 15.
Woodcock	Nov. 15–Dec. 15.
Duck (except wood duck, ruddy duck, bufflehead), goose (except Ross's goose), brant, coot Wilson's snipe or jacksnipe, Tuesdays, Wednesdays, Thursdays, Fridays, Saturdays	Nov. 6–Dec. 15.
Rail and gallinule, other than coot	Sept. 1–Nov. 30.

Hunting licenses: Nonresident, $15; resident, $1.10. For dog in hunting, $1.50. Guide, $10. Special local licenses required in Chico and Desha Counties. For information communicate with county clerks.

Bag and possession limits: 2 deer, 2 turkeys, a season; 8 squirrels, 3 pheasants, 3 prairie chickens, 12 quail, a day or in possession; 18 doves, 12 ducks (but not more than 5 of any one, or in the aggregate, of the following species—canvasback, redhead, scaup, ringneck, teal, shoveler, and gadwall), 4 geese, including brant, 4 woodcock, 12 Wilson's snipe, 15 in all of rails, coots, and gallinules, a day. Two days' limit of squirrels, quail, or ducks and 12 woodcock, may be possessed at one time except while in the field hunting or returning from a hunt of 1 day's duration. Possession of migratory game birds permitted during first 10 days of close season.

Interstate transportation: Export of all game prohibited; provided, a nonresident, under each of 3 tags attached to his license may ship out 1 day's limit of game; and he may carry out at one time not more than 1 day's limit, but not more than 2 days' limit (3 days' in the case of woodcock) may be removed from State in any 1 calendar week; specimen of game may be exported by any person under permit to be mounted, tanned, or made into wearing apparel.

Baiting: Doves may not be shot or otherwise taken by means of bait, nor may ducks, geese, or brant be taken on baited premises except under seasonal permits issued by the Biological Survey.

CALIFORNIA

Open seasons:	*Dates inclusive*
Male deer (except spike bucks):	
In districts 1, 1¾, 4½, 23, and 25	Sept. 16–Oct. 15.
In district 1½	Sept. 1–Oct. 15.
In districts 2, 2½, and 3	Aug. 1–Sept. 14.
In districts 2¼, 4, and 4¾	Aug. 16–Sept. 15.
Bear (black, brown)	Nov. 16–Feb. 28.
Cottontail and brush rabbits (see exception)	Nov. 15–Dec. 15.
Exception: Rabbits in districts 4, 4¾, 19, 21	No close season.
Quail (see exception)	Nov. 15–Dec. 31.
Exception: In district 1½	Nov. 1–Dec. 31.
Dove (see exception)	Sept. 1–Sept. 30.
Exception: In districts 4, 4½, 4¾	Sept. 1–Oct. 31.
Pheasant (male)	Nov. 15–Nov. 20.
Band-tailed pigeon	Dec. 1–Dec. 15.
Duck (except wood duck, ruddy duck, and bufflehead), goose (except Ross's goose), brant, coot (mud hen) Wilson's snipe or jacksnipe, Saturdays, Sundays	Oct. 20–Dec. 30.
Gallinule	Oct. 1–Nov. 30.

Hunting licenses: Nonresident, $10; alien, $25 (except those with first papers, $10). Resident, $2 (resident under 18, $1). Deer-tag license, $1. Commercial club: Citizen owner, $25; alien owner, $100; citizen operator, $5; alien operator, $25. Issued by commissioners and county clerks.

Bag and possession limits: 2 deer a season (except in district 1¾, 1 only); 15 rabbits a day, 30 a week; 10 mountain quail a day, 20 a week; 10 valley of desert quail a day, 20 a week; 20 Wilson's snipe a day, 50 a week; mourning doves, 15 a day, 30 a week; 10 band-tailed pigeons a day or in possession; 2 male pheasants a day or in possession; 12 ducks a day (but not more than 5 of any one, or in the aggregate, of the following species—eiders, canvasback, redhead, scaup, ringneck, teal, shoveler, and gadwall), but not more than 2 day's limit of waterfowl in possession at one time; 4 geese, including brant, a day, 8 in possession; 20 Wilson's snipe a day, 25 in possession; 25 coots (mud hen) a day or in possession; 15 gallinules a day or in possession. One day's bag limit of game lawfully taken may be possessed for 5 days after close of season, except that deer meat may be retained for 15 days after close of season. Game taken outside of State and legally exported may be possessed in like manner as game taken in State.

Interstate transportation: Export of all protected game, and shipments of same by parcel post, prohibited.

Baiting: Doves may not be shot or otherwise taken by means of bait, nor may ducks, geese, or brant be taken on baited premises except under seasonal permits issued by the Biological Survey.

Miscellaneous: The use of live decoys in the taking of wild geese is not permitted.

COLORADO

Open seasons:	*Dates inclusive*
Deer (with 2 or more prongs to each horn)	Oct. 12–Oct. 18.
Bear	No open season.
Bull elk, in Grand, Routt, Gunnison, Jefferson, Eagle, Clear Creek, Gilpin, Boulder, Summit Counties, Garfield County north of Colorado River, and Pitkin County east of Roaring Fork River only	Oct. 12–Oct. 18.
Rabbit, hare	No close season.
Prairie chicken	Sept. 15–Oct. 1.
Ringneck pheasant (male), in Adams, Arapahoe, Boulder, Jefferson, Larimer, Morgan, and Weld Counties only	Dec. 1–Dec. 5.
Mountain and willow grouse	Oct. 12–Oct. 21.
Sage chickens	Aug. 15–Aug. 20.
Duck (except wood duck, ruddy duck, and bufflehead), goose (except Ross's goose), brant, coot, Wilson's snipe or jacksnipe—	
Monday, Tuesday	Oct. 1–Oct. 2.
Saturdays, Sundays	Oct. 6–Jan. 6.
Rails and gallinules, other than coot	Sept. 1–Nov. 30.

Hunting licenses: Nonresident—big game, $25 small game, $5. Resident—big game, $5; small game and fish, $2. Guide, $5, in addition to hunting license. Issued by commissioner, county clerks, and other agents. Aliens not permitted to hunt.

Bag and possession limits: 1 deer or 1 elk a season, coupon required; 2 pheasants a day, 3 in possession; 8 prairie chickens a day or in possession; 8 in the aggregate of mountain and willow grouse and sage chickens a day or in possession; 12 ducks (but not more than 5 of any one, or in the aggregate of the following species—canvasback, redhead, scaup, ringneck, teal, shoveler, and gadwall) a day, but not more than 2 days' limit in possession; 4 geese, including brant, 20 Wilson's snipe, 25 sora, and 15 in all of other rails, coots, and gallinules, a day or in possession. Possession permitted during first 5 days of close season; but commissioner may issue permit (fee $1) authorizing storage, possession, and use of game for 90 days after close of season and game taken outside of State and legally exported may be possessed at any time (except possession of migratory game birds limited to 10 days after close of season).

Interstate transportation: Export of all protected game is prohibited; provided, game in not exceeding the numbers allowed in possession, may be exported under permit from game commissioner (fee, 25 cents for each bird) if permit be attached and packages plainly marked so as to show nature of contents, but not more than 2 days' limit of migratory birds shall be exported in any 1 calendar week; edible portion of deer may be exported under $5 permit from the commissioner. Importer must obtain from State game and fish commissioner a certificate, fee $1, to import game.

Baiting: Ducks, geese, and brant may not be taken on baited premises, except under seasonal permits issued by the Biological Survey.

CONNECTICUT

Open seasons:	*Dates inclusive*
Hare, rabbit (except European, Belgian, or German hare and jack rabbit, no close season)	Nov. 2–Dec. 31.
Gray squirrel	Oct. 20–Nov. 23.
Quail	Oct. 20–Nov. 23.
Partridge or ruffed grouse, Mongolian, Chinese, or English pheasant (male)	Oct. 20–Nov. 23.
Woodcock	Oct. 20–Nov. 19.
Duck (except wood duck, ruddy duck, and bufflehead), goose (except Ross's and snow geese and brant), coot (mud hen), Wilson's snipe or jacksnipe, Thursdays, Fridays, Saturdays	Oct. 18–Dec. 22.
Rail and gallinule, other than coot	Sept. 1–Nov. 30.

Hunting licenses: Nonresident, $10.35. Resident $3.35. Combination hunting and fishing, nonresident, $14.35; resident, $5.35. Issued by city, town, or borough clerk. Aliens not permitted to hunt.

Bag and possession limits: 3 hares or rabbits a day, 30 a season; 5 squirrels a day, 30 a season; 2 ruffed grouse, 2 pheasant a day, 15 each a season; quail, 3 a day, 10 a season; 12 ducks (but not more than 5 of any one, or in the aggregate, of the following species eiders, canvasback, redhead, scaup, ringneck, teal, shoveler, and gadwall) a day; 4 geese a day; but not more than 2 days' limit of ducks and geese may be possessed at one time; 4 woodcock a day, 12 in possession; 20 Wilson's snipe, 25 coots, 25 sora, and 25 of other rails and gallinules a day, but not more than 15 of any one species of rails and gallinules a day. Possession of more than the daily bag limit of game (except ducks and geese) prima facie evidence of violation. Resident may possess for his own use, but not for sale, during first 10 days of close season, game lawfully taken.

Game taken outside of State and lawfully exported may be possessed at any time, but migratory game birds may be possessed only during first 10 days of close season.

Interstate transportation: Export of all protected game prohibited; provided, a licensee under permit may export game lawfully killed and possessed and tagged to show name, address, and license number of shipper, if not for sale; but not more than 2 days' limit of migratory birds may be exported in 1 calendar week. To import game, importer must obtain permit from superintendent of fisheries and game.

Baiting: Ducks and geese may not be taken on baited premises, except under seasonal permits issued by the Biological Survey.

DELAWARE

Open seasons:	*Dates inclusive*
Rabbit, hare, quail, partridge	Nov. 15–Dec. 31.
Squirrel (gray)	Sept. 15–Nov. 1.
Squirrel (fox, black)	Nov. 15–Dec. 31.
Dove	Sept. 15–Nov. 1. Nov. 15–Dec. 15.
Woodcock	Nov. 15–Dec. 15.
Duck (except wood duck, ruddy duck, and bufflehead), goose (except Ross's and snow geese and brant), coot, Wilson's snipe or jacksnipe, Thursdays, Fridays, Saturdays	Oct. 25–Dec. 29.
Open seasons—Continued.	*Dates inclusive*
Rail and gallinule (not including coot)	Sept. 1–Nov. 30.

Hunting licenses: Nonresident, $15.50. Resident, game and fish, $1.10 (required outside of county of residence). Issued by commission.

Bag and possession limits: 6 in all of rabbits, hares, and squirrels a day; 12 ducks (but not more than 5 of any one, or in the aggregate, of the following species—eiders, canvasback, redhead, scaup, ringneck, teal, shoveler, and gadwall) a day; 4 geese; 20 Wilson's snipe, 4 woodcock, 12 coots, 12 sora, 12 in all of other rails and gallinules a day, and not more than 12 birds of any other species a day. Possession of migratory game birds permitted during first 10 days of close season, but not more than 2 days' limit of ducks and geese and not more than 12 woodcock may be possessed at one time. Upland birds may be possessed during first 5 days of close season.

Interstate transportation: Licensee may carry or ship openly, within or out of State, not more than 10 rabbits, 10 squirrels, 50 rails, and 20 birds of other species a week, but not more than 2 days' bag limit of other migratory game birds may be shipped or carried out in any 1 calendar week.

Baiting: Doves may not be shot or otherwise taken by means of bait. Ducks and geese may not be taken on any baited premises except under seasonal permits issued by the Biological Survey.

Miscellaneous: Unlawful to hunt game animals or birds when snow is on the ground.

FLORIDA

Open seasons:[3]	*Dates inclusive*
Deer (male) (see exception)	Nov. 20–Dec. 31.
Exception: In Sumter County	No open season.
Squirrel, wild turkey, quail (see exception)	Nov. 20–Feb. 15.
Exception: Wild turkey in Sumter County	No open season.
Dove (see exceptions)	Nov. 20–Jan. 31.
Exceptions: West of the Ochlockonee River	Nov. 1–Jan. 31.
In Dade, Monroe, and Broward Counties	Sept. 16–Nov. 15.
Duck (except wood duck, ruddy duck, and bufflehead), goose (except Ross' and snow geese and brant), coot, Wilson's snipe or jacksnipe, Thursdays, Fridays, Saturdays, Sundays	Nov. 22–Jan. 11.
Rail, other than coot and gallinule	Sept. 15–Nov. 30.
Gallinules	Nov. 20–Nov. 30.

Hunting licenses: Nonresident, $25.50. Resident, $8 (State); $3.25 (county other than county of residence); $1.25 (county of residence). Issued by county judge.

Bag and possession limits: 1 deer a day, 2 a season; 2 turkeys a day, 5 a season; 200 of any other species of game birds or animals a season; 15 squirrels, 15 quail, 18 doves a day; 12 ducks (but not more than 5 of any one, or in the aggregate, of the following species—canvasback, redhead, scaup, ringneck, teal, shoveler, and gadwall) a day; 4 geese, 15 Wilson's snipe, 20 coots, and 25 in all of rails and gallinules, but not more than 15 of any one species of rails and gallinules (other than coot) a day. Game lawfully taken may be possessed during open season and for 5 days thereafter, but not more than 2 days' bag limit may be possessed at one time.

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[3] *Florida.* In St. Johns County residents may hunt deer on Friday and Saturday from June 15 to Aug. 15. In Walton County, season is closed on turkeys until June 30, 1935, and season on all other game closed from Jan. 17 to Oct. 30 of each year. In Flagler County deer may be hunted only on Thursday and Friday of each week during June until June 30, 1938, and squirrel, quail, jacksnipe, and dove may be hunted only on Monday, Friday, and Saturday during open season. In Marion County all game except deer, and turkey may be hunted Nov. 20 to Jan. 31, but no game may be hunted except on Monday, Wednesday, and Friday during open season, except ducks and geese as above indicated. Killing of deer in Marion County must be reported to county judge, sheriff, or game warden, and certificate of such reporting obtained. Rails in State may be hunted only on salt marshes.

Interstate transportation: Export of all protected game prohibited, except that nonresident licensee may export game lawfully taken by himself, but not to exceed 2 deer and 5 turkeys a season, nor more than 2 days' limit of other game during any one calendar week.

Baiting: Game animals and birds may not be taken on any field or waters on which corn, wheat, or other grain or food has been deposited.

GEORGIA

Open seasons:	*Dates inclusive*
Deer (males only) (see exception)	Nov. 15–Jan. 5.
Exception: In Catoosa, Chattooga, Dade, Dawson, Fannin, Gilmer, Gordon, Habersham, Lumpkin, Murray, Pickens, Rabun, Stephens, Towns, Union, Walker, White, Whitfield, Bartow, Floyd, Marion, Schley, Webster, Chattahoochee, Muscogee, and Stewart Counties	No open season.
Bear	Nov. 20–Feb. 1.
Rabbit	No close season.
Cat squirrel (see exception)	Oct. 1–Jan. 15.
Exception: In Catoosa, Chattooga, Dade, Dawson, Fannin, Gilmer, Gordon, Habersham, Lumpkin, Murray, Pickens, Rabun, Stephens, Towns, Union, Walker, White, and Whitfield Counties	Aug. 15–Jan. 15.
Opossum	Oct. 1–Feb. 1.
Quail, wild turkey	Nov. 20–Mar. 1.
Doves	Sept. 1–Sept. 30, Nov. 20–Jan. 31.
Woodcock	Dec. 1–Dec. 31.
Duck (except wood duck, ruddy duck, and bufflehead), goose (except Ross' and snow geese and brant), coot, Wilson's snipe or jacksnipe, Thursdays, Fridays, Saturdays	Nov. 8–Jan. 12.
Rail (marsh hen) and gallinule, other than coot	Sept. 1–Nov. 30.

Hunting licenses: Nonresident, $25 (State); $10 (county of issue). Resident, State, $3.25; county, $1 (good only in county of residence). Issued by commissioner, county warden, or county ordinary.

Bag and possession limits: 2 deer, 2 turkeys, a season; 15 squirrels a day; 20 quail a day, 40 a week, 40 in possession; 12 ducks (but not more than 5 of any one, or in the aggregate, of the following species—canvasback, redhead, scaup, ringneck, teal, shoveler, and gadwall), 4 geese, 20 Wilson's snipe, 4 woodcock, 18 doves, 25 coots, 25 sora, and 25 in all of other rails and gallinules, but not more than 15 of any one species of rails and gallinules (other than sora), a day. Migratory game birds lawfully taken may be possessed first 10 days of close season, but not more than 2 days' limit of wild ducks and geese and not more than 12 woodcock may be possessed at any one time. Special permit required to possess other game birds and game animals during close season.

Interstate transportation: Export of all protected game prohibited; provided, nonresident licensee may take out in personal possession game lawfully killed, but not more than 2 days' limit of migratory birds may be exported in any 1 calendar week.

Game taken outside of State and legally exported may be imported and possessed under a permit in like manner as game taken in State. Permits issued by game and fish commissioner.

Baiting: Doves and other game birds may not be shot on, at, or near any area on which grain or other food has been placed or scattered.

HAWAII

Open seasons:	*Dates inclusive*
Deer (except on Molokai Island, no close season)	Apr. 1–Oct. 31.
Quail (except bobwhite) in Maui County	Nov. 1–Jan. 31.
In Hawaii County	Dec. 1–Jan. 31.
In Kauai County, and city and county of Honolulu [4]	No open season.
Pheasant (male) in Maui, Kauai, and Honolulu [4] Counties	Nov. 1–Jan. 31.
In Hawaii County	Dec. 1–Jan. 31.
Wild dove, wild pigeon in Honolulu [4] County	Sept. 1–Dec. 31
In Hawaii County	July 1–Jan. 31.
In Maui and Kauai Counties	July 1–Dec. 31.

Hunting licenses: County licenses—Nonresident citizens or declarant alien: Game, $10. Resident citizen: Game, $5. Alien: Game, $25. Hunting licenses issued by county treasurer.

Bag and possession limits: *Hawaii County:* Cock pheasants, 5 a day, 25 a season; quail, 15 a day, 30 in 7 consecutive days; doves and pigeons, 20 a day, 50 in 7 consecutive days. *Honolulu County:* Cock pheasants, 3 a day; doves and pigeons, 20 a day. *Kauai County:* Cock pheasants, 3 a day; doves and pigeons, 15 a day. *Maui County:* Cock pheasants, 5 a day, 10 in 7 consecutive days; quail, 10 a day, 25 in 7 consecutive days; doves and pigeons, 15 a day, 45 in 7 consecutive days.

IDAHO

Open seasons:	*Dates inclusive*
Elk, in Clearwater and Idaho Counties	Oct. 5–Nov. 10.
In Clark, Fremont, Jefferson, Madison, and Teton Counties	Nov. 15–Dec. 1.
In rest of State	No open season.
Deer, in Ada, Blaine, Boise, Butte, Custer, Elmore, Gem, Lemhi, Owyhee, and Valley Counties, and in Idaho County east of Main Salmon and south of Little Salmon	Oct. 5–Nov. 5.
In Clearwater County, and remainder of Idaho County	Oct. 5–Nov. 10.
In Clark, Fremont, Jefferson, Madison, and Teton Counties	Nov. 15–Dec. 1.
In Benewah, Bonner, Boundary, Kootenai, Latah, Lewis, Nez Perce, and Shoshone Counties	Nov. 1–Nov. 30.
In Bannock, Caribou, Franklin, and Oneida Counties	Oct. 20–Oct. 30.
In Adams and Washington Counties	Oct. 15–Nov. 15.
In Bear Lake County	Oct. 20–Oct. 24.
Mountain sheep (ram only, under special license), in Valley and Lemhi Counties only	Oct. 15–Oct. 25.
Mountain goat, in Adams, Blaine, Boise, Butte, Custer, Elmore, Lemhi, Valley, Idaho, and Clearwater Counties	Oct. 10–Oct. 20.
Bear (see exception)	No close season.
Exception: In Benewah, Bonner, Boundary, Clearwater, Kootenai, Latah, Lewis, Nez Perce, and Shoshone Counties	Sept. 1–May 31.

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[4] *Hawaii:* Hunting prohibited in city and county of Honolulu except on Saturdays, Sundays, and legal Territorial holidays.

Open seasons—Continued.	*Dates inclusive*
Ruffed grouse (native pheasant), blue grouse, in Adams, Bingham, Blaine, Boise, Bonneville, Camas, Cassia, Clark, Elmore, Fremont, Gem, Gooding, Jefferson, Jerome, Lemhi, Lincoln, Madison, Minidoka, Owyhee, Teton, Twin Falls, Valley, and Washington Counties	Aug. 10–Aug. 25.
In Clearwater, Idaho, Nez Perce, Lewis, and Latah Counties (Wednesdays, Fridays, Sundays, and National holidays only)	Sept. 1–Sept. 30.
In Benewah, Bonner, Boundary, Kootenai, and Shoshone Counties	Oct. 1–Oct. 15.
In rest of State	No open season.
Sharp-tailed grouse, in Blaine, Boise, Camas, Cassia, Elmore, Fremont, Gem, Gooding, Jerome, Lincoln, Minidoka, Owyhee, Twin Falls, and Valley Counties only	Aug. 10–Aug. 25.
Hungarian partridge, in Benewah, Bonner, Boundary, and Kootenai Counties	Nov. 1–Nov. 15.
In Clearwater, Idaho, Latah, Lewis, Nez Perce Counties (Wednesday, Friday, Sunday, and National holidays only)	Nov. 1–Nov. 30.
In Ada, Adams, Boise, Gem, Payette, and Washington Counties	Nov. 1–Nov. 15.
Sage hens, in Bannock, Bear Lake, Bingham, Blaine, Boise, Bonneville, Butte, Camas, Caribou, Cassia, Clark, Custer, Elmore, Franklin, Fremont, Gem, Gooding, Jefferson, Jerome, Lemhi, Lincoln, Madison, Minidoka, Oneida, Owyhee, Power, Teton, Twin Falls, and Valley Counties	Aug. 10–Aug. 25.
Quail, in Ada, Canyon, Elmore, Gem, Payette, Washington, and Twin Falls Counties	Nov. 1–Nov. 10.
In Nez Perce County (Sundays, Wednesdays, Fridays, and National holidays only)	Nov. 1–Nov. 30
Pheasant (Chinese, ringneck, mutant, and Mongolian), in Ada, Adams, Blaine, Canyon, Cassia, Elmore, Gem, Gooding, Jerome, Lincoln, Minidoka, Owyhee, Payette, Twin Falls, and Washington Counties	Oct. 15–Nov. 10.
In Bannock, Bingham, Bonneville, Jefferson, Lemhi, Madison, and Power Counties north and west of Snake River	Nov. 1–Nov. 10.
In Clearwater, Idaho, Latah, and Nez Perce Counties (Sundays, Wednesdays, Fridays, and National holidays only)	Nov. 1–Nov. 30.
Doves	Sept. 1–Dec. 15.
Duck (except wood duck, ruddy duck, and bufflehead), goose (except Ross's goose), brant, coot, Wilson's snipe or jacksnipe, Saturdays, Sundays	Oct. 6–Jan. 13.
Rails and gallinules, other than coot	Sept. 1–Nov. 30.

Hunting licenses: Nonresident, game and fish, $50; bird only, $10. Alien, game and fish, $75; gun license, $5. Resident $2. Special license for male mountain sheep in Valley and Lemhi Counties—nonresident, $50; resident, $25. Issued by warden, deputy, or authorized agent. Hunting license not required of Civil War veteran; children under 12 not permitted to hunt with firearms.

Bag and possession limits: 1 deer, 1 elk, 1 mountain goat, 1 mountain sheep, a season; 6 quail, 4 pheasants, 8 Hungarian partridge, 4 sage hens, native pheasant, or grouse, a day or in possession; 12 ducks (but not more than 5 of any one, or in the aggregate, of the following species—canvasback, redhead, scaup, ringneck, teal, shoveler, and gadwall), 4 geese, including brant, a day or in possession; 18 doves, 20 Wilson's snipe, 25 coots, 25 sora, and 25 in all of other rails and gallinules, but not more than 15 of any one species of rails and gallinules (other than sora), a day. Under affidavit and storage permit, migratory game birds may be retained in possession 10 days after close of season; other game may be possessed 5 days after close of season.

Interstate transportation: Export of all protected game prohibited, provided a hunter may export under hunting-license coupon, big game lawfully taken, and 1 day's limit of game birds may be transported in personal possession but may not be shipped or mailed. Big game once shipped within State may be exported under a 50-cent permit obtained from game warden or deputy. Mounted heads and stuffed birds legally obtained may be exported under a reshipping permit. Shipment of game by parcel post prohibited.

Game taken outside of State and legally exported may be possessed in like manner as game taken in State, if identification tags or shipping or possession permits are attached.

Baiting: Doves may not be shot or otherwise taken by means of bait, nor may ducks, geese, or brant be taken on baited premises except under seasonal permits issued by the Biological Survey.

ILLINOIS

Open seasons:	*Dates inclusive*
Rabbit	Nov. 10–Jan. 31.
Squirrel, in northern zone	Sept. 1–Dec. 1.
In central zone	Aug. 1–Dec. 1.
In southern zone	July 15–Dec. 1.
Quail (bobwhite)	Nov. 10–Dec. 10.
Introduced pheasant (cocks)	Nov. 10–Nov. 15.
Dove	Sept. 1–Sept. 30.
Duck (except wood duck, ruddy duck, and bufflehead), goose (except Ross's goose), brant, coot, Wilson's snipe or jacksnipe, Saturdays, Sundays	Oct. 6–Jan. 13.
Rail and gallinule, other than coot	Sept. 1–Nov. 30.

Hunting licenses: Nonresident, $15.50; resident, $1. Issued by village, county, or city clerk. Hunting club, $10; issued by department of conservation.

Bag and possession limits: 10 squirrels, 15 rabbits, 12 quail, 2 cock pheasants, 15 doves, 15 snipe, 15 in all of coots and gallinules, 15 rails but not more than 25 in all of rails, coots, and gallinules; 12 ducks (but not more than 5 of any one, or in the aggregate, of the following species—canvasback, redhead, scaup, ringneck, teal, shoveler, and gadwall), 4 geese, including brant, a day. Limit, in possession, 20 squirrels, 36 quail, 6 cock pheasants, 25 doves, 30 snipe, 30 rails, 24 ducks (but not more than 10 of any one, or in the aggregate, of the species above named), 8 geese, including brant.

Interstate transportation: Export of all protected game (except rabbit) prohibited; provided, nonresident licensee may take from State 50 game birds or animals, if carried openly for inspection, but not more than 2 days' limit of migratory birds may be exported in any 1 calendar week. Resident may carry out game under his license.

Deer lawfully killed and shipped may be brought or shipped into State, and rabbits may be imported November 10 to February 5.

Baiting: Doves may not be shot or otherwise taken by means of bait, nor may ducks, geese, or brant be taken on baited premises except under seasonal permits issued by the Biological Survey.

INDIANA

Open seasons:	*Dates inclusive*
Rabbit	Nov. 11–Jan. 10.
Squirrel (except red squirrel, no close season)	Aug. 1–Oct. 15.
Quail, ruffed grouse	Nov. 10–Dec. 20.
Prairie chicken	Oct. 15–Oct. 31.
Woodcock	Oct. 15–Nov. 14.
Duck (except wood duck, ruddy duck, and bufflehead), goose (except Ross's goose), brant, coot, Wilson's snipe or jacksnipe, Thursdays, Fridays, Saturdays	Oct. 4–Dec. 8.
Rail and gallinule, other than coot	Sept. 1–Nov. 30.

Hunting licenses: Nonresident, $15.50; resident, $1. Issued by circuit clerks, superintendent of fisheries and game and his agents.

Bag and possession limits: 10 rabbits, 5 squirrels (no limit on red squirrels), 15 quail, 5 prairie chickens, 12 ducks (but not more than 5 of any one, or in the aggregate, of the following species—canvasback, redhead, scaup, ringneck, teal, shoveler, and gadwall), 4 geese, including brant, a day; 20 Wilson's snipe, 4 woodcock, 25 sora, and 25 in all of other rails and gallinules, but not more than 15 of any one species of rails (other than sora) and gallinules, a day. Not more than 12 woodcock, 2 days' limit of ducks and geese, including brant and 3 days' limit of other migratory game birds, may be possessed at one time. Possession of migratory game birds permitted during first 10 days of close season.

Deer, turkeys, and rabbits taken outside of State and legally exported may be possessed at any time; other game legally exported may be possessed in like manner as game taken in State.

Interstate transportation: Export of deer, quail, grouse, prairie chicken, pheasant, wild turkey, and migratory game birds prohibited, except any licensee may export 15 game birds in the aggregate of all kinds, lawfully taken by himself, each day he hunts in State, but not more than daily limit of any one species, and not more than 2 days' limit of migratory game birds in any 1 calendar week, if carried openly for inspection together with his license or if the package is tagged or clearly labeled with names and addresses of shipper and consignee and an accurate statement of number and kind of birds.

Baiting: Ducks, geese, and brant may not be taken on any baited premises except under seasonal permits issued by the Biological Survey.

IOWA

Open seasons:[5]	*Dates inclusive*
Squirrel	Sept. 1–Nov. 1.
Rabbit	Sept. 15–Jan. 15.
Woodcock	No open season.
Duck (except wood duck, ruddy duck, and bufflehead), goose (except Ross's goose), brant, coot, Wilson's snipe or jacksnipe Wednesday, Thursday, Friday, Saturday, Sunday	Oct. 10–Nov. 18.
Rail and gallinule, other than coot	No open season.

Hunting licenses: Nonresident or alien, $15; resident, 16 years of age and over, $2; resident under 16, $1; combined hunting and fishing, $2.50. Issued by county recorder and authorized agents.

Bag and possession limits: 10 squirrels, 15 rabbits a day; 2 days' limit, but not more than 30 in the aggregate, in possession. 12 ducks (but not more than 5 of any one, or in the aggregate, of the following species—canvasback, redhead, scaup, ringneck, teal, shoveler, and gadwall), 4 geese, including brant, a day; 15 Wilson's snipe, 30 in the aggregate of game birds in possession, but not more than 2 days' limit of ducks, 8 geese including brant, and 15 each of other species in possession at one time.

Game taken outside of State and legally exported may be possessed at any time, except that migratory game birds may be possessed only during the open season and for 10 days immediately thereafter.

Interstate transportation: Export of all protected game prohibited, except that nonresident may take from State 15 game birds and animals lawfully killed, if open to inspection, and hunting license be shown on request, but not more than 2 days' bag limit of migratory game birds may be exported in any one calendar week.

Baiting: Regulations of the commission prohibit the baiting of any area with food for the purpose of attracting game birds.

KANSAS

Open seasons:	*Dates inclusive*
Quail	Nov. 20–Nov. 30.
Prairie chicken (2 days)	Oct. 16–17.
Dove	Sept. 1–Oct. 15.
Duck (except wood duck, ruddy duck, and bufflehead), goose (except Ross's goose), brant, coot, Wilson's snipe or jacksnipe, Thursdays Fridays, Saturdays	Oct. 11–Dec. 15.
Rails, other than coot and gallinule	Sept. 1–Nov. 30.
Gallinule	Oct. 1–Nov. 30.

Hunting licenses: Nonresident, $7; resident, $1 (county of residence and adjoining counties), $3 (state-wide). Issued by county clerk.

Bag and possession limits: 10 quail a day, 25 a season; 5 prairie chickens a day, 10 a season; 15 in all of ducks, Wilson's snipe, coots, and gallinules a day, but not more than 12 ducks (5 of any one, or in the aggregate, of the following species—canvasback, redhead, scaup, ringneck, teal, shoveler, and gadwall); 18 doves, 4 in all of geese and brant, 6 rails, a day. Possession of 2 days limit of 2 kinds of game permitted during first 5 days of close season, but not more than 2 days' limit of wild ducks and wild geese including brant may be possessed at any one time.

Interstate transportation: Export of all protected game birds prohibited, except that a person under hunting license and affidavit of lawful killing and possession may ship to himself not more than 2 days' limit of 2 kinds of game taken by himself. Game of not more than 2 kinds, and not more than 2 days' bag limit, taken outside of State and legally exported, may be possessed during open season and first 5 days of close season.

Baiting: Doves may not be shot or otherwise taken by means of bait, nor may ducks, geese, or brant be taken on baited premises except under seasonal permits issued by the Biological Survey.

Miscellaneous: Unlawful to shoot game birds while they are on the ground or water, unless wounded.

KENTUCKY

Open seasons:	*Dates inclusive*
Rabbit	Nov. 15–Dec. 31.
Squirrel	Aug. 1–Nov. 30.
Introduced pheasant (male)	Nov. 15–Nov. 19.
Quail	Nov. 24–Jan. 9.
Wild turkey, ruffed grouse (native pheasant)	No open season.
Dove	Sept. 1–Dec. 15.
Woodcock	Nov. 15–Dec. 15.
Duck (except wood duck, ruddy duck, and bufflehead), goose (except Ross's goose), brant, coot, Wilson's snipe or jacksnipe, Fridays, Saturdays, Sundays	Nov. 2–Jan. 6.
Rail and gallinule, other than coot	Sept. 14–Nov. 30.

Hunting licenses: Nonresident or alien, $10.50; resident, $1. Issued by county clerk.

Bag and possession limits: 12 squirrels a day, 24 in possession; 12 quail a day, 24 in possession, 75 a season; 15 doves a day, 15 in possession for each successive day of hunt; 2 ruffed grouse, 2 pheasant, 12 ducks (but not more than 5 of any one, or in the aggregate, of the following species—canvasback, redhead, scaup, ringneck, teal, shoveler, and gadwall); 4 geese, including brant; 4 woodcock; 20 Wilson's snipe, and 25 in all of rails, coots, and gallinules, but not more than 15 of any one species of rails (other than sora) and gallinules a day. Not more than 2 days' bag limit of wild ducks and wild geese and not more than 12 woodcock may be possessed at one time. Game taken outside of State and legally exported may be possessed in like manner as game taken in State.

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[5] *Iowa:* Communicate with State Fish and Game Commission for seasons on pheasants and quail.

Interstate transportation: Export of deer, elk, and all game birds prohibited, except that a hunter may transport game lawfully killed and possessed by him, but not more than 2 days' limit of migratory birds may be exported in any 1 calendar week.

Baiting: Doves may not be shot or otherwise taken by menas of bait, nor may they be shot before 12 o'clock noon. Wild ducks, geese, and brant may not be taken on baited premises except under seasonal permits issued by the Bureau of Biological Survey.

LOUISIANA

Open seasons:	*Dates inclusive*
Deer (male)	Nov. 1–Jan. 15.
Bear	Nov. 1–Jan. 1.
Rabbit, hare	Oct. 1–Mar. 1.
Squirrel	Sept. 15–Jan. 15.
Quail	Nov. 1–Feb. 15.
Wild turkey	No open season.
Woodcock	Dec. 1–Dec. 31.
Dove	Dec. 1–Jan. 31.
Duck (except wood duck, ruddy duck, and bufflehead), goose (except Ross's goose), brant, coot, Wilson's snipe or jacksnipe, Fridays, Saturdays, Sundays	Nov. 2–Jan. 6.
Rails and gallinules, other than coot	Nov. 15–Jan. 31.

Hunting licenses: Nonresident $15; nonresident 4-day license, $5. Resident, $1. Club or association, $5. Alien, general, $50; game birds, $25 Issued by tax collectors.

Bag and possession limits: 1 deer, 1 bear a day, 5 each a season; 10 squirrels and chipmunks combined a day, 120 a season; 15 quail a day, 120 a season; 18 doves a day, 300 a season; 12 ducks (but not more than 5 of any one, or in the aggregate, of the following species—canvasback, redhead, scaup, ringneck, teal, shoveler, and gadwall) a day, 300 a season; 4 geese, including brant, a day; 25 coot, 25 sora, and 25 in all of other rails and gallinules, but not more than 15 of any one species of rails, other than sora, and gallinules, a day; 4 woodcock a day, 22 a season, 12 in possession. Game in excess of 1 days' limit must be tagged, but not more than 2 days' limit of wild ducks and geese, including brant, may be possessed at one time. Possession of game birds permitted during first 10 days of close season.

Game taken outside of State and legally exported may be possessed at any time, except migratory game birds as above stated.

Interstate transportation: Export of all protected game prohibited; provided a nonresident licensee may carry with him out of the State under his license and tag 2 days' limit of game birds, if not for sale. All game and all packages containing game must be tagged to show kind and number, names of consignor and consignee, initial point of billing, and destination.

Baiting: Doves may not be shot or otherwise taken by means of bait; nor may wild ducks, geese, or brant be taken on baited premises except under seasonal permits issued by the Biological Survey.

MAINE

Open seasons:	*Dates inclusive*
Deer, in Androscoggin, Cumberland, Kennebec, Knox, Lincoln, Sagadahoc, Waldo and York Counties	Nov. 1–Nov. 30.
In Aroostook, Penobscot, Somerset, Piscataquis, Franklin, and Oxford Counties	Oct. 16–Nov. 30.
In Hancock and Washington Counties	Nov. 1–Dec. 15.
Bear	Oct. 1–Nov. 30.
Hare, rabbit (see exception)	Oct. 1–Feb. 28.
Exception: In Franklin County	Oct. 1–Mar. 31.
Gray squirrel	Oct. 1–Oct. 31.
Ruffed grouse or partridge	Oct. 1–Nov. 15.
Woodcock	Oct. 1–Oct. 31.
Duck (except wood duck, ruddy duck, and bufflehead), goose (except Ross's and snow geese, and brant), coot, Wilson's snipe or jacksnipe, Thursdays, Fridays, Saturdays,	Oct. 4–Dec. 8.
Rails and gallinules, other than coot	Sept. 1–Nov. 30.

Hunting licenses: Nonresident or alien, big game, $15.15; small game, $5.15. Resident, hunting and fishing, $1.15; hunting, 65 cents. Issued by city town, and plantation clerks. Guide license: Nonresident, $20; resident, $1. Sporting camp, $5. Shipping license (within State); Resident, deer, $2; 1 pair of game birds in 7 days, 50 cents; issued by commissioner.

Bag and possession limits: 1 deer a season; 4 ruffed grouse a day, 25 a season; 12 ducks (but not more than 5 of any one or in the aggregate, of the following species—eiders, canvasback, redhead, scaup, ringneck, teal, shoveler, and gadwall), 4 geese, 20 Wilson's snipe, 4 woodcock, 25 coots, 25 sora, and 25 in all of other rails but not more than 15 of any one species of rails (other than sora) and gallinules, a day. Not more than 2 days' bag limit of wild ducks, and wild geese, and not more than 12 woodcock may be possessed at any one time. Deer may not be possessed in lumber camps, and must be transported open to view, tagged and labeled with name and address of, and accompanied by, owner. Possession of migratory game birds limited to first 10 days of close season.

Interstate transportation: Export of all protected game prohibited; provided, a citizen of the State, under transportation tag (fee, $5) may take with him out of State game birds lawfully killed by himself. A nonresident licensee may take out, open to view, hares lawfully taken by himself, 1 deer, 4 partridges, 2 days' bag limit of ducks, geese, woodcock, and snipe, under hunting-license tags, when such tags bear written approval of a warden, deputy, or the commissioner. Nonresident licensee may also ship out 1 pair of game birds a month under a special 50-cent license.

Moose or caribou, or parts thereof, taken outside of State and legally exported may be imported under license of commissioner for consumption or mounting, but not for sale. Deer properly tagged where taken and game birds may be imported under permit of commissioner and possessed in like manner as game killed in State. Permits and shipping tags issued by commissioner of inland fisheries and game.

Baiting: Wild ducks and geese may not be taken on baited premises except under seasonal permits issued by the Biological Survey.

Miscellaneous: Not more than 12 live decoys may be used by one boat or blind in hunting migratory waterfowl.

MARYLAND

Open seasons:	*Dates inclusive*
Deer (male, with 2 or more points to one antler), in Allegany County	Dec. 1–Dec. 10.
In Garrett County	Dec. 1–Dec. 5.
In Washington County, in game reserves enclosed with 7-foot fence	Dec. 1–Dec. 15.
In rest of State	No open season.
Rabbit or hare, quail (partridge), ruffed grouse, wild turkey, and English or ring-necked, Mongolian, and black pheasant (males only)	Nov. 15–Dec. 31.
Squirrel (see exception)	Sept. 15–Oct. 15, Nov. 15–Dec. 31.
Exception: In Garrett County	Oct. 1–Oct. 31.
Raccoon, opossum	Nov. 1–Jan. 31.
Dove	Sept. 1–Sept. 30, Nov. 15–Dec. 15.
Woodcock	Nov. 15–Dec. 15.

Open seasons—Continued.	*Dates inclusive*
Duck (except wood duck, ruddy duck, and bufflehead), goose except Ross's and snow geese and brant), coot, Wilson's snipe or jacksnipe, Thursdays Fridays, Saturdays	Nov. 8–Jan. 12.
Rails and gallinules, other than coot	Sept. 1–Oct. 31.

Hunting licenses: Nonresident, $15.50 ($5.50 for State license if applicant owns real estate in Maryland assessed at $500; $1.50 for county license in county where such real estate is located). Nonresident, 5-day license, $5.50; resident: State, $5.25; county, $1.25. Issued by circuit-court clerks (in Baltimore City by clerk of court of common pleas). Booby, brush, or stake blind, $5.50 (not issued except to resident of State, or nonresident owner of land bordering on Potomac River, or nonresident owner of land bordering on any waters of the State and assessed at $500); pushers, $2.50. Issued by circuit-court clerks. *Susquehanna Flats*: Sinkbox, $20.75; sneakboat, $5.75.

Bag and possession limits: 1 deer a season; 1 turkey a day, 4 a season; 2 English or Mongolian pheasants, 2 ruffed grouse a day, 6 a season; 6 rabbits or hares, 10 squirrels, 10 quail (partridge), 4 woodcock, 18 doves, 20 jacksnipe, 25 coots, 25 in all of rails and gallinules, but not more than 15 of any one species of rails (except sora) and gallinules, a day; 12 ducks (but not more than 5 of any one or in the aggregate, of the following species—eiders, canvasback, redhead, scaup, ringneck, teal, shoveler, and gadwall), and 4 geese a day. Not more than 2 days' bag limit of ducks and geese and 3 days' limit of woodcock may be possessed at one time. Game taken outside of State and legally exported may be possessed in like manner as game taken in State.

Interstate transportation: Export of all protected game (except waterfowl) prohibited; provided, a licensed hunter my take out under his license as personal baggage a quantity equal to 2 days' bag limit of game; provided further, no person may take or ship out more than 2 days' bag limit of ducks and geese in any one calendar week. Water-fowl must be shipped open to view and tagged.

Baiting: Doves may not be shot or otherwise taken by means of bait; nor may wild ducks or geese be taken on baited premises except under seasonal permits issued by the Biological Survey.

MASSACHUSETTS

Open seasons:	*Dates inclusive*
Deer (see exception)	Dec. 3–Dec. 8.
Exception: In Barnstable and Nantucket Counties	No open season.
Hare, rabbit (see exception)	Oct. 20–Feb. 15.
Exception: In Nantucket County	Nov. 20–Feb. 28.
In Dukes County	Nov. 15–Feb. 15.
Gray squirrel, quail, male pheasant, ruffed grouse (see exceptions)	Oct. 20–Nov. 20.
Exceptions: Quail, in Berkshire, Essex, Franklin, Hampden, Hampshire, Middlesex, Nantucket, and Worcester Counties	No open season.
Pheasant, in Dukes County	No open season.
Woodcock	Oct. 20–Nov. 19.
Duck (except wood duck, ruddy duck, and bufflehead), goose (except Ross', and snow geese and brant), coot, Wilson's snipe or jacksnipe, Thursdays, Fridays, Saturdays	Oct. 18–Dec. 22.
Rail and gallinule, other than coot	Oct. 4–Nov. 2.

Hunting licenses: Nonresident citizen: Sporting, $15.25; hunting, $10.25. Nonresident who owns real estate in State assessed at not less than $1,000 or is a member of a hunting club assessed at not less than $1,000 for each member, same fee as resident. Resident citizen: Sporting, $3.25; hunting, $2. License not required of resident citizen over 70 years of age. Permanent gunning stand or blind, $2.75. Issued by director of fisheries and game, department of conservation, city and town clerks.

Bag and possession limits: 1 deer a season; 2 hares, 5 rabbits, a day or in possession; 5 gray squirrels a day, 15 a season; 4 quail a day, 20 a season; 2 pheasants a day, 6 a season; 3 ruffed grouse a day, 15 a season; 4 woodcock, 12 ducks (but not more than 5 of any one, or in the aggregate, of the following species—eiders, canvasback, redhead, scaup, ringneck, teal, shoveler, and gadwall), 4 geese, 20 Wilson's snipe, 25 coots, 25 sora, and 25 in all of other rails and gallinules, but not more than 15 of any one species of rails and gallinules (other than sora and coot) a day. A resident may possess for his own use during the close season game legally taken by himself, but migratory game birds may be possessed only during the open season and first 10 days of close season. Not more than 2 days' limit of migratory waterfowl and not more than 12 woodcock may be possessed at any one time. Game taken outside of State and legally exported may be possessed for personal use.

Interstate transportation: A nonresident under his license may take out fish and game lawfully taken if carried open to view. A resident may export all game lawfully killed, but not more than 2 days' bag limit of migratory birds may be exported in any one calendar week.

Baiting: Wild ducks and geese may not be taken on any baited premises except under seasonal permits issued by the Biological Survey.

MICHIGAN

Open seasons: [6]	*Dates inclusive*
Deer (male with horns not less than 3 inches above skull), in Upper Peninsula, and in Alcona, Alpena, Antrim, Arenac, Bay, Cheboygan, Crawford, Charlevoix (except Beaver Island), Emmet, Gladwin, Iosco, Kalkaska, Midland, Montmorency, Ogemaw, Oscoda, Otsego, Presque Isle, and Roscommon Counties	Nov. 15–Nov. 30.
In rest of State	No open season.
Bear	Nov. 15–Nov. 30.
Rabbit, varying hare, in Upper Peninsula	Oct. 1–Jan. 31.
In Lower Peninsula	Oct. 15–Jan. 31.
Fox squirrel, in Upper Peninsula	Oct. 1–Oct. 10.
In Lower Peninsula	Oct. 15–Oct. 24.
Prairie chicken, ringneck pheasant (male), ruffed grouse (partridge), woodcock, in Lower Peninsula	Oct. 15–Oct. 26.
Prairie chicken, ruffed grouse, in Upper Peninsula	Oct. 1–Oct. 12.
Ringneck pheasant, woodcock, in Upper Peninsula	No open season.
Duck (except wood duck, ruddy duck, and bufflehead), goose (except Ross' goose), brant, coot, Wilson's snipe or jacksnipe, rails and gallinules, Wednesdays, Thursdays, Fridays, Saturdays, Sundays	Oct. 3–Nov. 11.

Hunting licenses: Nonresident—deer and bear, $25; small game, $5. Resident—deer and bear, $2.25; small game, $1. Issued by county clerks, director of conservation, or deputy. Camping party (1 deer for use of party of 4 or more), $3; issued by director of conservation.

Bag and possession limits: 1 deer, 1 bear a season; 5 fox squirrels a day, 10 in possession, 15 a season; 5 rabbits a day, 5 in possession in Upper Peninsula, 10 in possession in Lower Peninsula, 50 a season; 5 each of ruffed grouse and prairie chickens a day, 10 each a season or in possession; 2 ringneck pheasants a day, 4 a season or in possession; 12 ducks a day, 24 in possession (but not more than 5 of any one, or, in the aggregate, of the following species: canvasback, redhead, scaup, ringneck, teal, shoveler, and gadwall a day; 10 of any one, or in the aggregate, in possession), 100 a season; 4 geese, including brant, a day, 8 a season, but not more than 5 in the aggregate of both in possession; 4 woodcock a day, 8 in possession, 16 a season; 10 Wilson's snipe a day, 20 in possession, 50 a season; 10 coots a day, 20 in possession, 50 a season; 10 rails and gallinules a day, 20 in possession, 50 a season. Deer and bear lawfully killed may be possessed first 60 days of close season; game birds and other animals during first 10 days of close season.

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[6] *Michigan:* Director of conservation may shorten or close seasons and otherwise restrict taking of game for period not to exceed 5 years in any county.

Game taken outside of State and lawfully exported may be possessed in like manner as game taken in State.

Interstate transportation: Export prohibited of all protected game. *Exceptions:* (1) Deer and bear may be transported outside of State to reach a point within State. (2) Nonresident licensee may take out as hand baggage, open to view, possession limit of game birds, rabbits, and squirrels, and may ship 1 deer and 1 bear lawfully killed by himself when deer license tag and seal are attached. (3) Heads and skins of deer and bear, green or mounted, lawfully taken, may be exported under permit.

Baiting: Wild ducks, geese, and brant may not be taken on baited premises except under seasonal permits issued by the Biological Survey.

MINNESOTA

Open seasons:[7]	*Dates inclusive*
Deer (season closed in odd, open in even years)	Nov. 15–Nov. 25.
Bear, even years	Nov. 15–Nov. 25.
Odd years	Apr. 15–May 15.
Varying hare or snowshoe rabbit	No close season.
Squirrel (gray or fox)	Oct. 15–Jan. 1.
Chinese ringneck, or English pheasants (male only), in Houston, Fillmore, Mower, Winona, Olmsted, Dodge, Wabasha, Norman, Clay, and Wilkin Counties	Oct. 20–Oct. 28.
In Freeborn, Faribault, Martin, Jackson, Nobles, Rock, Pipestone, Murray, Cottonwood, Watonwan, Blue Earth, Waseca, Steele, Goodhue, Rice, LeSueur, Nicollet, Brown, Redwood, Lyon, Lincoln, Yellow Medicine, Renville, Sibley, Scott, Dakota, Washington, Hennepin, Carver, McLeod, Wright, Meeker, Kandiyohi, Chippewa, Lac qui Parle, Big Stone, Swift, Traverse, Stevens, Pope, Stearns, Sherburne, Anoka, Chisago, Isanti, Pine, Kanabec, Mille Lacs, Benton, Morrison, Todd, Douglas, Grant, Ottertail, Wadena, Crow Wing, Aitkin, Carlton, Cass, Hubbard, Becker Counties	Oct. 20–Nov. 4.
Prairie chicken (pinnated grouse), white-breasted (sharp-tailed) grouse, in Kittson, Roseau, Lake of the Woods, Koochiching, St. Louis, Marshall, Polk, Pennington, Red Lake, Mahnomen, Clearwater, Beltrami, and Itasca Counties only	Sept. 16–Sept. 24.
Ruffed grouse (partridge), in Kittson, Roseau, Lake of the Woods, Marshall, Pennington, Red Lake, Polk, Mahnomen, Clearwater, Becker, Hubbard, Crow Wing, Morrison, Mille Lacs, Goodhue, Winona, Fillmore, and Houston Counties	Oct. 20–Oct. 28.
In Cook, Lake, St. Louis, Koochiching, Beltrami, Itasca, Cass, Carlton, Pine, Aitkin, and Kanabec Counties	Oct. 20–Nov. 4.
In rest of State	No open season.
Quail, in Sherburne, Wright, Carver, Sibley, Scott, Dakota, Olmsted, Winona, Fillmore, and Houston Counties only	Oct. 20–Nov. 4.
Duck (except wood duck, ruddy duck, and bufflehead), goose (except Ross's goose), brant, coot, Wilson's snipe or jacksnipe, rails, and gallinules, Wednesdays, Thursdays, Fridays, Saturdays, Sundays	Oct. 3–Nov. 11.

Hunting licenses: Nonresident or alien, big game, $50.25; small game, $25. Resident, big game, $2.25; small game, $1. Issued by commissioner, county auditors, and agents.

Bag and possession limits: 1 deer a season; 7 squirrels a day, 14 in possession; 3 pheasants a day, 18 a season, 6 in possession; 6 in aggregate of prairie chicken and white-breasted grouse a day, 18 a season, 12 in possession; 5 ruffed grouse (partridge) a day, 30 a season, 10 in possession; 6 quail a day, 30 a season, 12 in possession; 12 each of ducks, coots, rails, and jacksnipe a day, but not more than 5 of any one, or in the aggregate, of the following species —canvasback, redhead, scaup, ringneck, teal, shoveler, and gadwall; 2 days' bag of ducks, may be possessed at one time; 4 geese, including brant, a day, 5 in possession. Not more than 15 in the aggregate of all game birds may be taken in 1 day. Possession permitted during first 5 days of close season. Under permit and tag, deer may be possessed until February 28, and migratory game birds may be possessed for 10 days after close of season, but no game birds may be possessed later than January 10. Game taken outside of State and legally exported may be possessed in like manner as game taken in State.

Interstate transportation: Export of all protected game prohibited, except that nonresident licensee may ship home in open season under his license coupons 1 deer and 25 birds lawfully taken by himself, but not more than the possession limit of any one species a season; not more than 5 geese, including brant, may be exported by one licensee. Deer hides for tanning and heads for mounting may be exported when tagged with license coupons (deer season closed in odd years).

Baiting[8]: Wild ducks, geese, and brant may not be taken on baited premises.

MISSISSIPPI

Open seasons:	*Dates inclusive*
Deer (male) (see exception)	No open season.
Exception: In Bolivar, Washington, Issaquena, Sunflower, Leflore, Tallahatchie, Quitman, Panola, Tunica, Sharkey, Yazoo, Humphreys, Grenada, Warren, Claiborne, Jefferson, Adams, Wilkinson, Jackson, George, Greene, and Wayne Counties	Dec. 15–Jan. 15.

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[7] *Minnesota:* Seasons subject to change by regulation. All hunting prohibited within 3 miles of corporate limits of Duluth, Minneapolis, and St. Paul.

[8] By proclamation of Sept. 15, 1934, the Governor prohibited the baiting or feeding of migratory waterfowl under permit, except that feeding may be permitted on sanctuaries by the State department of conservation.

Open seasons—Continued.	*Dates inclusive*
Raccoon, rabbit	Nov. 20–Jan. 31.
Opossum	Oct. 1–Jan. 31.
Squirrel	Oct. 1–Dec. 31.
Fox (see exception)	No close season.
Exception: In Kemper, Jefferson Davis, Copiah, Covington, Jefferson, Lauderdale, Madison, Neshoba, Newton, Pike, Rankin, Simpson, and Smith Counties	Sept. 1–Feb. 28.
In Amite, Franklin, and Wilkinson Counties	Oct. 1–Feb. 28.
Bear	No open season.
Quail	Dec. 10–Feb. 20.
Pheasant	No open season.
Wild turkey (gobbler) (see exception)	Apr. 1–Apr. 20.
Exception: In Alcorn, Benton, Calhoun, Carroll, Chickasaw, Choctaw, Clay, Coahoma, DeSoto, Grenada, Itawamba, Lafayette, Lee, Leflore, Lowndes, Marshall Monroe, Montgomery, Oktibbeha, Panola, Pontotoc, Prentiss, Quitman, Tallahatchie, Tate, Tippah Tishomingo, Tunica, Union, Webster, and Yalobusha Counties	No open season.
Woodcock	Dec. 1–Dec. 31.
Mourning dove	Sept. 1–Sept. 30. Nov. 20–Jan. 31.
Duck (except wood duck, ruddy duck, and bufflehead), goose (except Ross's goose), brant, coot, Wilson's snipe or jacksnipe, Tuesdays, Wednesdays, Thursdays, Fridays, Saturdays	Nov. 6–Dec. 15.
Rails and gallinules, other than coot	Sept. 1–Nov. 30.

Hunting licenses: Nonresident, $25.25 (State); $10.25 (county). Resident, $3.25 (State); $1.25 (county). Issued by game and fish commission, sheriffs, and wardens.

Bag and possession limits: 1 male deer, 1 wild turkey gobbler a season; 10 rabbits a day; 8 squirrels a day, 24 in possession; 12 quail a day; 12 ducks (but not more than 5 of any one, or in the aggregate, of the following species—canvasback, redhead, scaup, ringneck, teal, shoveler, and gadwall), 4 geese (including brant), 20 Wilson's snipe, 4 woodcock, 18 doves, 25 coots, 25 sora, 25 of other rails (except sora) and gallinules, but not more than 15 of any one species of rails and gallinules (other than sora and coot), a day. Not more than 2 days' bag limit of ducks and geese and not more than 12 woodcock may be possessed at one time.

Interstate transportation: Export of all protected game prohibited, except rabbits and the skins of raccoons and opossums may be exported November 20 to January 31. Nonresident licensee may ship or carry out of State during open season 1 buck deer, 20 rabbits, 16 squirrels, raccoons, and opossums in possession, 30 quail, 1 turkey gobbler, and, in 1 calendar week, not to exceed 2 days' bag limit of migratory game birds (3 days' limit of woodcock). Packages must have attached an affidavit that game was lawfully killed, is being shipped to licensee's home, and is not for sale.

Baiting: Doves may not be shot or otherwise taken by means of bait. Wild ducks, geese, and brant may not be taken on baited premises except under seasonal permits issued by the Biological Survey.

MISSOURI

Open seasons:	*Dates inclusive*
Deer (male, with 4 or more points to 1 antler), 3 days only	Oct. 25–Oct. 27
Squirrel	June 1–Nov. 30.
Wild turkey	Dec. 1–Dec. 31.

Open seasons—Continued.	*Dates inclusive*
Quail (bobwhite) (see exceptions)	Nov. 10–Dec. 31.
Exceptions: In Andrew, Atchison, Bates, Cooper, Dade, Daviess, De Kalb. Harrison, Johnson, Knox, Maries, Moniteau, and Schuyler Counties	No open season.
In Cass County	Dec. 4–Dec. 31.
Dove	Sept. 1–Dec. 15.
Woodcock	Nov. 10–Dec. 10.
Duck (except wood duck ruddy duck, and bufflehead), goose (except Ross's goose), brant, coot, Wilson's snipe or jacksnipe, Fridays, Saturdays, Sundays	Oct. 19–Dec. 23.
Rail and gallinule, other than coot	Sept. 15–Nov. 30.

Hunting licenses: Nonresident or alien, $10; issued by commissioner or county clerk. Resident—State, $2.50; county, $1 (county of residence or adjoining county). Issued by county clerk or license collector. Special deer tag required in addition to hunting license—resident, $1.50, nonresident, $50.

Bag and possession limits: 1 deer, 1 turkey a season; 10 squirrels, 10 quail, 10 doves, 12 ducks (but not more than 5 of any one, or in aggregate, of the following species—cavansback, redhead, scaup, ringneck, teal, shoveler, and gadwall), 4 geese, including brant, 4 woodcock, 15 Wilson's snipe, a day; 15 rails, 15 coot, 15 gallinules, a day, but not more than 25 in all of rails and gallinules. One turkey, 15 quail, 15 doves, 8 geese, including brant, and 25 of any other species of game birds, in possession, but not more than 12 woodcock and not more than 2 days' limit of ducks in possession at one time. Possession of migratory game birds permitted during first 10 days of close season, other game during first 5 days, but tagged carcass of deer may be possessed until February 5.

Game taken outside of State and legally exported may be possessed in like manner as game taken in State.

Interstate transportation: Export of all protected game prohibited, except that not more than 2 days' limit of game may be exported under resident or nonresident license if carried openly as baggage or express or in owner's possession and accompanied by him.

Baiting: Doves may not be shot or otherwise taken by means of bait. Wild ducks, geese, and brant may not be taken on baited premises except under seasonal permits issued by the Biological Survey.

MONTANA

Open seasons:	*Dates inclusive*
Deer (male, with horns not less than 4 inches long) (see exceptions)	Oct. 15–Nov. 15.
Exceptions: In Carter, Custer, Dawson, Fallon, Prairie, Richland, Roosevelt, and Wibaux Counties	Nov. 1–Nov. 3.
In part of Ravalli County (either sex)	Sept. 20–Oct. 20.
In Mineral, Glacier (except in Lewis and Clark National Forest no open season), Lake, Sanders, Missoula, Granite, and Ravalli Counties (either sex)	Oct. 15–Nov. 15.
In Blaine, Carbon, Daniels, Garfield, Liberty, McCone, Musselshell, Petroleum, Phillips, Powder River, Rosebud, Sheridan, Teton, Toole, Treasure, Valley, Yellowstone, and parts of Big Horn, Gallatin, and Pondera Counties	No open season.

Open seasons—Continued.	*Dates inclusive*
Elk, in Flathead, Glacier, Pondera, Petroleum, and Madison Counties; part of Missoula, Powell, and Gallatin Counties, and one of either sex in part of Mineral County	Oct. 15–Nov. 15.
In Park County	Oct. 15–Jan. 10.
In part of Ravalli County	Sept. 20–Oct. 20.
In part of Granite County (either sex)	Nov. 12–Nov. 15.
In part of Lewis and Clark County	Nov. 1–Nov. 15.
In part of Lewis and Clark and Teton Counties	Oct. 15–Dec. 1.
In rest of State	No open season.
Bear (unlawful to trap)	No close season.
Grouse (sharp-tailed, blue, ruffed, fool hen), prairie chicken, sage hen	Sept. 16–Sept. 25.
Duck (except wood duck, ruddy duck, and bufflehead), goose (except Ross's goose), brant, coot, Wilson's snipe or jacksnipe Fridays, Saturdays, Sundays	Oct. 5–Dec. 9.
Rails and gallinules, other than coot	Sept. 16–Nov. 30.

Hunting licenses: Resident—class A, game birds and fishing, $2; class AA game animals, $1 (issued only to holder of class A license); class AAA ("sportsman's license"), general hunting and fishing, $5. Nonresident—class B-1, game birds, $10; class B-2, general hunting, $30. Alien—class C-1, game birds, $30; class C-2, game animals, $50. Guide (resident citizen only), $10. Issued by warden, deputies, justices of the peace, and agents. Alien not holding class C-2 license must obtain from warden license to own or possess firearms (fee, $25).

Bag and possession limits: 1 deer, 1 elk a season; 5 in all of grouse, partridges, fool hens, pheasants, and sage hens a day or in possession; 12 ducks (but not more than 5 of any one, or in the aggregate, of the following species—canvasback, redhead, scaup, ringneck, teal, shoveler, and gadwall), 4 geese, including brant, 20 Wilson's snipe, 25 coots, 25 sora, 25 in all of other rails and gallinules but not more than 15 of any 1 species of rails (other than sora) and gallinules, a day. Migratory game birds may be possessed during first 10 days of close season, but not more than 2 days' limit of ducks and geese may be possessed at any one time. Game taken outside of State and legally exported may be possessed in like manner as game taken in State.

Interstate transportation: Export of all protected game prohibited; provided, game lawfully killed may be exported by a resident under shipping permit (fee, 50 cents) from State warden; a nonresident may export under his license game he has lawfully taken; total shipments under permits or one license may not exceed season's bag limit and not more than 2 days' limit of migratory birds may be exported in any one calendar week; packages must be labeled to show contents.

Baiting: Wild ducks, geese, and brant may not be taken on baited premises except under seasonal permits issued by the Biological Survey.

NEBRASKA [9]

Open seasons: [9]	*Dates inclusive*
Squirrel	Oct. 1–Dec. 31.
Rabbit	No close season.
Duck (except wood duck, ruddy duck, and bufflehead), goose (except Ross's goose), brant, coot, rail, and gallinule	Oct. 16–Nov. 14.
Wilson's snipe or jacksnipe	Oct. 1–Nov. 1.

Hunting licenses: Nonresident, $10.10; resident, $1.10. Issued by game, forestation, and parks commission and authorized vendors.

Bag and possession limits: 10 squirrels a day or in possession; 5 pheasants a day or in possession; 20 ducks and coot combined a day, but not more than 12 ducks a day, except that not more than 5 of any one, or in the aggregate, of the following species—canvasback, redhead, scaup, ringneck, teal, shoveler, and gadwall—may be taken in 1 day; 4 geese, including brant, a day, 5 in possession; 15 Wilson's snipe a day or in possession; 25 in all of rails and gallinules a day, but not more than 15 of each a day or in possession. Not more than 2 days' bag limit of ducks may be possessed at one time. Game taken outside of State and legally exported may be possessed in like manner as game taken in State, but migratory game birds may be possessed only during open season and first 10 days of close season.

Interstate transportation: Game may be transported by express or baggage during the open season when tagged as required by commission, and shipper's statement that the game is not for sale or profit, and was not taken contrary to law, is furnished commission and a copy attached to shipment; package must be labeled with consignor's license number and kind of game, consigned to shipper, and accompanied by him; shipment must not contain more than 40 game birds or the possession bag limit on any species. Not more than 2 days' limit of migratory birds may be exported in any one calendar week.

Baiting: Wild ducks, geese, and brant may not be taken on baited premises except under seasonal permits issued by the Biological Survey.

NEVADA

Open seasons: [10]	*Dates inclusive*
Deer (male) (see exceptions)	Oct. 7–Nov. 5.
Exceptions: In Elko, Esmeralda, Lander, Nye, and Pershing Counties	Oct. 7–Oct. 21.
In Eureka and White Pine Counties	Oct. 7–Oct. 27.
In Humboldt County	Oct. 7–Oct. 20.
In Lincoln and Mineral Counties	Oct. 7–Oct. 22.
Rabbit, hare (see exceptions)	Nov. 4–Dec. 31.
Exceptions: In Churchill County	Nov. 4, 5.
In Pershing County	Nov. 4–Nov. 18.
In Eureka and White Pine Counties (rabbit only)	Nov. 4–Dec. 4.
In Eureka, Humbolt, and White Pine Counties (hares only)	No open season.
Bear, squirrel	No close season.
Pheasant (see exceptions)	No open season.
Exceptions: In Churchill County	Nov. 4, 5.
In Clark, Lander, Nye, and Storey Counties	Nov. 4–Nov. 18.
In Lyon County	Nov. 4, 5, 6.
In Mineral County	Nov. 4–Nov. 10.
Grouse (see exceptions)	Nov. 4–Nov. 18.
Exceptions: In Churchill, Eureka, Humboldt, Lincoln, Pershing, and White Pine Counties	No open season.
In Elko County	Oct. 7–Oct. 21.
In Washoe County	Nov. 4, 5, 6.
Valley quail, mountain quail (see exceptions)	Nov. 4–Nov. 18.
Exceptions: In Churchill County (valley quail)	Nov. 4, 5.
In Douglas County (valley quail)	Nov. 4.
In Humboldt and Mineral Counties (valley quail)	Nov. 4–Nov. 10.
In Lincoln and Washoe Counties (valley quail)	Nov. 4, 5, 6.
In Elko, Esmeralda, Eureka, and White Pine Counties (valley quail)	No open season.
In Lyon and Washoe Counties (mountain quail)	Nov. 4, 5, 6.
In Mineral County (mountain quail)	Nov. 4–Nov. 10.

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[9] *Nebraska:* Game, Forestation, and Parks Commission, upon written request from any county board, may open season on pheasants, prairie chickens, and grouse in such county for 15 days or less between Sept. 16 and Dec. 31.

[10] *Nevada:* Fish and game commission fixes open seasons on deer and upland game birds, and county commissioners may shorten or close season entirely on all game.

Open seasons—Continued.	*Dates inclusive*
Valley quail—Continued.	
Exceptions—Continued.	
In Churchill, Elko, Esmeralda, Eureka, Humboldt, and White Pine Counties (mountain quail)	No open season.
Dove (see exceptions)	Sept. 1–Sept. 30.
Exceptions: In Churchill County	Sept. 1–Sept. 10.
In Lincoln County	Sept. 1–Sept. 15.
In Pershing County	Sept. 1–Sept. 16.
Duck (except wood duck, ruddy duck, and bufflehead), goose (except Ross's goose), brant, coot, Wilson's snipe or jacksnipe, Monday and Tuesday	Oct. 1 and 2.
Saturdays and Sundays	Oct. 6–Jan. 6.
Rail and gallinule, other than coot	Sept. 1–Nov. 30.

Hunting licenses: Nonresident citizen and declarant alien, $10; alien, $25; resident citizen, $2.50. Deer tags ($1) required of holders of licenses to hunt deer. Issued by county clerks and wardens.

Bag and possession limits: 1 deer a season; 5 rabbits, 2 hares, 10 valley quail, 5 mountain quail, 3 partridges, 3 pheasants, 10 sagehens, 3 grouse, 5 prairie chickens, 12 ducks (but not more than 5 of any one, or in the aggregate, of the following species—convasback, redhead, scaup, ringneck, teal, shoveler, and gadwall) a day; 4 geese, including brant, 10 Wilson's snipe, 18 doves, 25 coot, 25 sora, and 25 in all of other rails and gallinules, but not more than 15 of any one species of rails (other than sora) and gallinules, a day. Possession limited to 1 day's bag limit, except that 8 in the aggregate of geese and brant, but not more than 5 of either, may be possessed at one time. One day's limit of game lawfully taken may be possessed, under permit, during first 60 days of close season, except that migratory game birds may be possessed only during first 10 days of close season. Deer lawfully taken in another State may be personally brought into State by the taker during close season, and game taken outside of State and lawfully exported may be possessed in like manner as game taken in State.

Interstate Transportation: Export of all protected game prohibited, except 1 day's limit may be exported under permit, if not for sale.

Baiting: Doves may not be shot or otherwise taken by means of bait. Wild ducks, geese, and brant may not be taken on baited premises except under seasonal permits issued by the Biological Survey.

NEW HAMPSHIRE

Open seasons:	*Dates inclusive*
Deer (see exceptions)	Dec. 15–Dec. 31.
Exceptions. In Coos County north of U. S. Highway No. 2 from Shelburne to Lancaster	Oct. 15–Nov. 30.
In Grafton County, and in Coos County south of U. S. Highway No. 2	Nov. 1–Dec. 15.
In Carroll County	Nov. 15–Dec. 15.
In Cheshire County	Dec. 1–Dec. 15.
In towns of Seabrook, Hampton, Hampton Falls, North Hampton, and Rye, in Rockingham County	No open season.
Hare, rabbit	Oct. 1–Feb. 28.
Partridge, ruffed grouse	Oct. 1–Nov.30.
Pheasant (male) in Hillsborough, Merrimack, Rockingham, and Strafford Counties only	Nov. 1–Nov. 6.
Quail	No open season.
Woodcock	Oct. 1–Oct. 31.
Duck (except wood duck, ruddy duck, and bufflehead), goose (except Ross's, and snow geese, and brant), coot, Wilson's snipe or jacksnipe, Fridays, Saturdays, Sundays	Oct. 5–Dec. 9.
Rail, other than coot and gallinule	Sept. 1–Nov. 30.
Gallinule	Sept. 16–Nov. 30.

Hunting licenses: Nonresident, game and fish, $15.15; resident, game and fish, $2. Guide—nonresident, $20; resident, $1. Issued by commissioner or his agent, who, with few exceptions, is the town clerk.

Bag and possession limits: 1 deer a season; 3 hares, 5 rabbits, but not more than 5 in all, a day; 5 ruffed grouse a day, 25 a season; 2 pheasants a day, 5 a season; 4 woodcock a day, 25 a season; 12 ducks (but not more than 5 of any one, or in the aggregate, of the following species—eiders, canvasback, redhead, scaup, ringneck, teal, shoveler, and gadwall) a day; 4 geese, 20 Wilson's snipe, 25 coots, 25 sora, and 25 in all of other rails and gallinules, but not more than 15 of any one species of rails (other than sora) and gallinules, a day. Not more than 2 day's bag limit of ducks and geese and not more than 12 woodcock may be possessed at one time. Deer may be possessed for a reasonable time after close of season. Migratory game birds may be possessed during first 10 days of close season. Game taken outside of State and legally exported may be possessed in like manner as game taken in State.

Interstate transportation: Export of all protected game prohibited, provided, head, hide, feet, or fur of game quadrupeds, and plumage or skins of game birds (except migratory birds) legally taken and possessed may be transported in State without being marked, but under Federal laws all interstate shipments must be marked as to contents. Nonresident may take or ship out of State, under his hunting license, 1 day's limit of game birds, and under license coupon, one deer. Shipments by common carrier must have attached tag showing number and kind of game, names of consignor and consignee, and point of shipment and destination, and shipment or transportation of game must be endorsed on back of shipper's license. Carcass of deer shipped by nonresident must have license coupon attached.

Baiting: Wild ducks and geese may not be taken on baited premises except under seasonal permits issued by the Biological Survey.

NEW JERSEY

Open seasons:	*Dates inclusive*
Deer (male, with horns not less than 3 inches long)	Dec. 17–Dec. 21.
Raccoon (may not be hunted during deer season)	Nov. 1–Dec. 31.
Rabbit, gray fox, and black squirrels, quail, ruffed grouse (partridge), prairie chicken, English or ring-necked pheasant cocks (see exceptions)	Nov. 10–Dec. 15.
Exceptions: Quail in Bergen, Essex, Hudson, Hunterdon, Morris, Passaic, Somerset, Sussex, Union, and Warren Counties	June 21, 1938.
Ruffed grouse in Essex, Hunterdon, Mercer, Middlesex, Monmouth, Somerset, and Union Counties	Mar. 9, 1935.
Woodcock	Oct. 15–Nov. 14.
Duck (except wood duck, ruddy duck, and bufflehead), goose (except Ross's and snow geese and brant), coot, Wilson's snipe or jacksnipe—Thursdays, Fridays, and Saturdays	Oct. 18–Dec. 22.
Rail and gallinule, other than coot	Sept. 1–Nov. 30.

Hunting licenses: Nonresident and alien, $10.50; resident, hunting and fishing, $3.15; resident, hunting only, $2.15. Issued by county, city, and town clerks, salaried wardens, and registrars of licenses. Special license to hunt woodcock between October 15 and November 9 (fee $2) required in addition to regular hunting license; issued by commission. Alien prohibited from hunting or owning shotgun or rifle unless he is owner of real property in State valued at $2,000 or over, above encumbrances, in which case he may obtain nonresident and alien license.

Bag and possession limits: 1 deer a season; 15 raccoons a season; 2 pheasant cocks a day, 30 a season; 6 rabbits, 6 squirrels, 10 quail, 3 ruffed grouse, 4 woodcock, 20 snipe, 25 sora, 25 coots, and 25 in all of other rails and gallinules (but not more than 15 of any one species of rails, other than sora, and gallinules), a day or in possession; 12 ducks (but not more than 5 of any one, or in the aggregate, of the following species—eiders, canvasback, redhead, scaup, ringneck, teal, shoveler, and gadwall), 4 geese a day. Not more than 2 day's limit of ducks and geese and not more than 12 woodcock may be possessed at one time. Carcass of deer from another State or from State game preserve may be possessed at any time if properly tagged; possession of other game permitted during first 10 days of close season. Game taken outside of State and legally exported may be possessed at any time, but migratory game birds may be possessed only during first 10 days of close season.

Interstate transportation: Export of all protected game (except deer) prohibited, except that a nonresident licensee in 1 day may carry from State the daily bag limit of game, if open to view, but not more than 2 days' limit of game may be exported in 1 calendar week.

Baiting: Wild ducks and geese may not be taken on baited premises except under seasonal permits issued by the Biological Survey.

NEW MEXICO

Open seasons:	*Dates inclusive*
Deer (with horns at least 6 inches long) elk,[11] squirrel, wild turkey (see exception)	Oct. 25-Nov. 15.
Exception: Deer and turkey in McKinley County	No open season.
Antelope,[11] in Catron and Socorro Counties only	Oct. 1-Oct. 5.
Bear	Oct. 1-Dec. 10.
Quail (except bobwhite) (see exception)	Nov. 10-Dec. 10.
Exception: In McKinley County	No open season.
Prairie chicken in Harding, Roosevelt, and Lea Counties only	Sept. 21-Sept. 25.
Dusky or blue grouse	Oct. 1-Oct. 10.
Doves	Sept. 1-Dec. 15.
Band-tailed pigeon	Nov. 1-Nov. 15.
Duck (except wood duck, ruddy duck, and bufflehead), goose (except Ross's goose), brant, coot, Wilson's snipe or jacksnipe—Saturdays and Sundays	Oct. 13-Jan. 13.
Rail and gallinule, other than coot	Sept. 1-Nov. 30.

Hunting licenses: Nonresident—general hunting and fishing, $35.25; general hunting, $30.25; big game, $25.25; bird, $10.25. Resident—general hunting and fishing, $5; general hunting, $4.50; big game, $3; bird, $2.50. Guide, $5.25. Duplicate license, $1. Issued by county clerks and designated deputy game wardens. Alien not permitted to hunt or own or possess shotgun or rifle in State.

Bag and possession limits: 1 deer, 1 bear, 5 squirrels, 2 wild turkeys, 10 prairie chickens, 5 grouse, a season or in possession; 12 quail a day or in possession; 5 prairie chickens a day; 15 doves, 10 band-tailed pigeons, 12 ducks (but not more than 5 of any one, or in the aggregate, of the following species—canvasback, redhead, scaup, ringneck, teal, shoveler, and gadwall), 4 geese, including brant, 20 Wilson's snipe, 25 coot, 25 sora, and 25 in all of other rails and gallinules, but not more than 15 of any one species of rails (other than sora) and gallinules, a day or in possession, except that not more than 2 days' bag limit of ducks and geese including brant, may be possessed at any one time.

Under permit game, except migratory game birds, may be held in storage first 90 days of close season, but migratory birds may be possessed only during first 10 days, and deer carcass until January 31 if tag accompanying license is attached.

Game taken outside of State and legally exported, when accompanied by proof of lawful possession, may be retained under permit for first 30 days of close season, but migratory game birds may be retained only during first 10 days.

Interstate transportation: Licensee may carry out of State during open season game legally killed, but permits issued by State game warden and license collectors are required to ship game out by common carrier: Fee, $1.25 for 1 deer, 1 bear, and 2 turkeys, and 50 cents for bag limit of other birds and fish.

Baiting: Doves may not be shot or otherwise taken by means of bait. Wild ducks, geese, and brant may not be taken on baited premises except under seasonal permits issued by the Biological Survey.

NEW YORK

Open seasons:	*Dates inclusive*
Deer (with horns not less than 3 inches long), in Adirondack[12] region	Oct. 15-Nov. 15.
In Ulster, Sullivan, Rensselaer, Delaware, Columbia, Orange, Schoharie, Dutchess, and Greene Counties	Nov. 1-Nov. 15.
In rest of State	No open season.
Bear (see exceptions)	Oct. 15-Nov. 15.
Exception: In Clinton, Delaware, Essex, Franklin, Greene, and Ulster Counties	Oct. 15-Dec. 31.
Varying hare (see exceptions)	Oct. 15-Jan. 31.
Exceptions: In Chautauqua and Fulton Counties	Oct. 25-Jan. 31.
In Allegany, Cattaraugus, Madison, Yates, Wyoming, Livingston, Niagara, Tompkins, and Chemung Counties	No open season.
Rabbit (see exceptions)	Oct. 15-Jan. 31.
Exceptions: In Wayne, Ontario, Orleans, Livingston, Cayuga, Schuyler, Tompkins, and Onondaga Counties	Oct. 15-Mar. 31.
In Niagara County	Oct. 25-Dec. 31.
In Rockland County	Nov. 15-Jan. 15.
In Erie County	Oct. 15-Jan. 1.
Squirrel (black, gray) (see exceptions)	Oct. 15-Nov. 15.
Exception: In Genesee, Niagara, Orleans, and Yates Counties	No open season.
Quail, in Putnam and Westchester Counties only	Nov. 1-Nov. 15.
Grouse or partridge	Oct. 15-Nov. 15.
Pheasant (male only)	Oct. 29-Nov. 3.
Woodcock, north of main track of New York Central Railroad, from Buffalo to Albany, and Boston & Albany Railroad to Massachusetts line	Oct. 1-Oct. 31.
In rest of State	Oct. 15-Nov. 14.
Duck (except wood duck, ruddy duck, and bufflehead), goose (except Ross's and snow geese and brant), coot, Wilson's snipe or jacksnipe, rails, and gallinules, Thursdays, Fridays, Saturdays	Oct. 4-Dec. 8.

Hunting licenses: Nonresident (combined hunting, fishing, and trapping), $10.50; resident, $2.25. Special deer license—Nonresident or alien, $10.50; resident, $1.25. Issued by county, city, and town clerks where population exceeds 5,000; elsewhere, by department of conservation inspectors and protectors. Indian resident or member of Six Nations residing on any reservation wholly or partly in State, $2.25. Guide (required in forest reserve counties), $2; issued by conservation department. Alien not permitted to hunt except under special license from conservation department, or to own or possess shotgun or rifle.

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[11] *New Mexico:* State game warden may issue 150 special permits (fee $5 each) to holders of big game hunting licenses, to take one buck antelope in a restricted area in Catron and Socorro Counties only, and elk in a designated area, under special permit (fee $10).

[12] *New York:* The Adirondack region comprises the counties of Clinton, Essex, Franklin, Fulton, Hamilton, Herkimer, Jefferson, Lewis, Oneida, Oswego, Saratoga, St. Lawrence, Warren, and Washington.

Bag limits: 1 deer, 1 bear, a season; 4 quail a day, 10 a season; 3 grouse or partridges a day, 15 a season; 2 male pheasants a day, 6 a season; 4 woodcock, 6 varying hares or rabbits, 5 squirrels, a day; 12 ducks (but not more than 5 of any one, or in the aggregate, of the following species, eiders, canvasback, redhead, scaup, teal, ringneck, shoveler, and gadwall), 4 geese, 25 in all of rails and gallinules, but not more than 15 of any one species of rails (except sora) and gallinules, a day; 5 coots, 25 sora, 20 Wilson's snipe, or jacksnipe a day.

Possession: Deer, bear, squirrel, grouse, and pheasant may be possessed during open season and 5 days thereafter; migratory game birds during open season and 10 days thereafter, but not more than 2 days' bag limit of ducks and geese and not more than 12 woodcock may be possessed at any one time. Deer and bear properly tagged may be possessed under permit (fee $1) until February 1. Game taken outside of State and legally exported may be imported during the open season and possessed in like manner as game taken in State, except migratory game birds may be possessed only during open season where taken and for 10 days thereafter. Permit (fee $1) from conservation department required for importation of game during close season, and then game birds must be accompanied by the taker, but quadrupeds bearing State tags may be shipped by common carrier but not by parcel post. Game, other than migratory game birds, imported under permit may be possessed at any time by permit holder for private consumption.

Interstate transportation: Export of game and birds prohibited except that any person may export 1 deer, 1 bear, and 1 day's limit of other game in 1 day during open season by means other than parcel post. The taker may export in 1 day by common carrier, except parcel post, 1 day's limit when accompanied by permit, which shall show contents of package. Head, hide, and feet of animals and plumage or skin of game birds legally taken may be exported at any time.

Baiting: Wild ducks and geese may not be taken on baited premises except under seasonal permits issued by the Biological Survey.

NEW YORK—Long Island

Open seasons:	*Dates inclusive*
Squirrel (black, gray), varying hare, rabbit, quail, pheasant (male), grouse	Nov. 1–Dec. 31.
Woodcock	Oct. 15–Nov. 14.
Waterfowl (except wood duck, ruddy duck, and bufflehead; Ross's and snow geese and brant), rail, gallinule, coot, mud hen, Wilson's snipe or jacksnipe, Thursdays, Fridays, Saturdays	Oct. 25–Dec. 29.

Bag and possession limits: 6 quail a day, 40 a season; 4 male pheasants a day, 30 a season. For other bag limits, see New York.

Hunting licenses, interstate transportation, and baiting, see New York.

NORTH CAROLINA

Open seasons:[13][14]	*Dates inclusive*
Deer (male), in western and central zones	Oct. 15–Dec. 15.
In eastern zone	Sept. 1–Dec. 15.
Bear, in western and central zones	Oct. 1–Jan. 15.
In eastern zone	No close season.
Rabbit, in western zone	Nov. 15–Jan. 1.
In central zone	Nov. 20–Feb. 20.
In eastern zone	Nov. 20–Feb. 1.
Squirrel, in western zone	Oct. 1–Nov. 30.
In central and eastern zones	Oct. 1–Dec. 31.
Raccoon, opossum	Nov. 1–Jan. 31.
Quail, turkey, in western zone	Nov. 15–Jan. 1.
In central zone	Nov. 20–Feb. 20.
In eastern zone	Nov. 20–Feb. 1.
Dove	Sept. 1–Sept. 30, Nov. 20–Jan. 31.
Woodcock	Dec. 1–Dec. 31.
Duck (except wood duck, ruddy duck, and bufflehead), goose (except Ross' and snow geese and brant), coot, Wilson's snipe or jacksnipe, Thursdays, Fridays, Saturdays	Nov. 8–Jan. 12.
Rail and gallinule other than coot	Sept. 1–Nov. 30.
Local seasons (upland game only):	
In Halifax, Northampton, Hertford, Person, Martin, Bertie, and Washington Counties:	
Deer	Sept. 1–Jan. 1.
Raccoon	Oct. 1–Feb. 1.
Squirrel	Sept. 15–Feb. 1.
Quail, turkey	Nov. 20–Feb. 20.
In Bertie, Bladen, and Duplin Counties, rabbit	No close season.
In Beaufort County:	
Deer	Sept. 15–Dec. 31.
Squirrel	Oct. 15–Dec. 31.
All other game	Nov. 15–Jan. 31.
In Bladen County:	
Deer	Oct. 15–Nov. 30.
Bear	No close season.
Squirrel	Oct. 15–Jan. 1.
Quail	Nov. 20–Jan. 31.
Turkey	Oct. 15–Jan. 1.
In Catawba County:	
Quail	No open season.
All other game	Nov. 20–Feb. 1.
In Cumberland, Transylvania, Harnett, and Nash Counties, all game	Nov. 20–Feb. 20.
In Graham County, raccoon, opossum	Nov. 1–Feb. 15.
In Yadkin County, quail	Dec. 1–Dec. 31.

Hunting licenses: Nonresident or alien: Game, $10.10. Nonresident owning land in State may obtain license to hunt thereon, fee, $5.25. Resident (State licenses): Game, $2.10. County licenses: Game, 60 cents. Hunting guide license, $5. Issued by superior court clerks, wardens, and deputies.

Bag and possession limits: 2 deer a day or in possession at one time, 4 a season; 2 wild turkeys a day or in possession at one time, 5 a season; 10 squirrels, 10 quail, 4 woodcock, 18 doves, 12 ducks (but not more than 5 of any one, or in the aggregate, of the following species—canvasback, redhead. scaup, ringneck, teal, shoveler, and gadwall), 4 geese, 20 Wilson's snipe, or jacksnipe, and 25 in all of rails, coots, and gallinules, but not more than 15 of any one species of rails (other than sora) and gallinules a day.

The game allowed in possession at one time is restricted to 1 day's limit on deer and wild turkeys, 2 days' limit on other game animals and birds, and to 12 woodcock.

Rabbits and squirrels lawfully taken may be possessed during open season and first 5 days of close season. Other game animals and birds may be possessed during open season and first 10 days of close season.

Game taken outside of State and legally exported may be possessed in like manner as game taken in State.

Interstate transportation: Export of all protected game (except rabbits during open season) prohibited, except that a nonresident licensee, under permit from State warden may export not more than

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[13] *North Carolina:* Western zone comprises Alleghany, Ashe, Watauga, Avery, Mitchell, Yancey, Buncombe, and Henderson Counties and all counties west thereof; eastern zone comprises Halifax, Nash, Johnston, Harnett, Hoke, and Scotland Counties, and all counties east thereof; central zone comprises rest of State.

[14] Season closed throughout State on ruffed grouse and pheasant.

2 male deer and 2 wild turkeys a season and not more than 2 days' limit of other game animals and birds (3 days' limit of woodcock) a calendar week in any manner except by parcel post, if outside of package in which such game is transported is clearly marked with names and addresses of consignor and consignee and an accurate statement of number and kind of game contained therein.

Baiting: Doves may not be shot or otherwise taken by means of bait. Wild ducks and geese may not be taken on baited premises except under seasonal permits issued by the Biological Survey.

NORTH DAKOTA

Open seasons:	*Dates inclusive*
Deer	No open season.
Prairie chicken (pinnated grouse), sharp-tailed (white breasted) grouse	Sept. 22–Oct. 1.
Ruffed grouse, in Bottineau, Cavalier, Pembina, and Rolette Counties	Sept. 28–Oct. 1.
Hungarian partridge, in Divide, Burke, Renville, Bottineau, and Rolette Counties, and in parts of Williams, Mountrail, Ward, McHenry, Pierce Counties	Oct. 6–Oct. 7.
Chinese ringneck, Mongolian, and English pheasants (male), in Richland, Ransom, Sargent, Dickey, and LaMoure Counties only	Oct. 20–Nov. 2.[15]
In Kidder, McIntosh, Stutsman, Emmons, Burleigh, Morton, Stark, Dunn, Cass, Barnes, Logan, Adams, Hettinger, Oliver, McLean, Grant, and Mercer Counties only	Oct. 20–Oct. 26.[15]
Duck (except wood duck, ruddy duck, and bufflehead), goose (except Ross's goose), brant, coot, Wilson's snipe or jacksnipe, Wednesdays, Thursdays, Fridays, Saturdays, Sundays	Oct. 3–Nov. 11.

Hunting licenses: Nonresident, big game, $50; hunting, $25. Resident, big game, $5; hunting, $1.50. Issued by game and fish commissioner, deputy, or county auditor. Alien not permitted to hunt.

Bag and possession limits: Prairie chicken (pinnated grouse), sharptailed (white breasted) grouse, ruffed grouse, 5 of each or of all combined a day, but not more than 10 of each or of all combined in possession; Hungarian partridge, 3 a day, 6 in possession; Chinese ringneck, Mongolian, and English pheasants, 3 a day, 6 in possession during the period October 20 to October 26, but in Richland, Ransom, Sargent, Dickey, and LaMoure Counties the daily bag limit during the period October 27 to November 2 is 5, not more than 2 of which may be hen birds, and the possession limit 10, not more than 4 of which may be hens. Four geese, including brant, a day, 8 in possession. Ducks, 12 of each or of all combined a day (but not more than 5 of any one, or 5 in the aggregate, of canvasbacks, redheads, scaup, ringneck, teal, shoveler, and gadwall), and not more than 2 days' bag limit of each or of all combined in possession. Ten jacksnipe, 12 coots a day.

Game taken outside of State and legally exported may be possessed in like manner as game taken in State. Upland game birds may be possessed 30 days, migratory game birds 10 days, and deer 90 days after close of season.

Interstate transportation: Export of all protected game prohibited, except that resident licensee may, under special permit, ship to any point within or without State, other than his own home, 10 protected game birds a season; but not more than 8 wild geese, including brant, may be shipped in any one calendar week. Nonresident licensee may carry with him from State under license tag 2 days' limit of game, if open to view and labeled with his name and address and number of his license. Not more than 2 days' limit of migratory birds may be exported in any one calendar week.

Baiting: Wild ducks, geese, and brant may not be taken on baited premises except under seasonal permits issued by the Biological Survey.

OHIO

Open seasons:	*Dates inclusive*
Hare, rabbit	Nov. 15–Jan. 1.
Squirrel	Sept. 15–Oct. 1.
Introduced pheasant (male), Hungarian partridge	Nov. 15–Nov. 25.
Woodcock	Oct. 15–Nov. 14.
Duck (except wood duck, ruddy duck, and bufflehead), goose (except Ross's goose), brant, coot, Wilson's snipe or jacksnipe, gallinule, Thursdays, Fridays, Saturdays	Oct. 4–Dec. 8.
Rail, other than coot and gallinule	Nov. 1–Nov. 30.

Hunting licenses: Nonresident citizen, $15.25; resident citizen, $1.25. Issued by county and township clerks and other authorized agents.

Bag and possession limits: 4 squirrels and 5 rabbits a day or in possession; 2 cock pheasants a day, 4 in possession; and 4 Hungarian partridges, 15 Wilson's snipe, 4 woodcock, 4 geese including brant, 12 ducks (but not more than 5 of any one, or in the aggregate, of the following species—canvasback, redhead, scaup, ringneck, teal, shoveler, and gadwall), 25 coots, 25 sora, and 25 in all of other rails and gallinules, but not more than 15 of any one species of rails (other than sora) and gallinules, and not more than 25 coots and gallinules a day. Waterfowl, coots, and gallinules may be possessed during first 10 days of close season, but not more than 2 days' bag limit of ducks and geese, including brant, and not more than 12 woodcock may be possessed at any one time. Woodcock and jacksnipe may be possessed only during open season.

Game taken outside of State and legally exported may be possessed in like manner as game taken in State.

Interstate transportation: Export prohibited of all protected game (except rabbit) taken in State; provided, a nonresident may take with him from State under his hunting license 25 game animals killed by himself. Packages containing game or fur-bearing animals or parts thereof must be marked to show contents, initial point of billing, and names and addresses of consignor and consignee.

Baiting: Wild ducks, geese, and brant may not be taken on baited premises except under seasonal permits issued by the Biological Survey.

OKLAHOMA

Open seasons:	*Dates inclusive*
Squirrel	May 15–Dec. 31.
Quail [16]	Nov. 20–Jan. 1.
Dove	Sept. 1–Dec. 15.
Woodcock	Nov. 15–Dec. 15.
Duck (except wood duck, ruddy duck, and bufflehead), goose (except Ross's goose), brant, coot, Wilson's snipe or jacksnipe, Saturdays, Sundays, Mondays,	Oct. 20–Dec.24.
Rail and gallinule, other than coot	Sept. 1-Nov. 30.

Hunting licenses: Nonresident, $15. Nonresidents in States bordering on Red River may procure special license (fee, $2.50) to hunt migratory waterfowl on Red River within borders of Oklahoma. Alien, $25. Resident citizen, $1.25. Issued by warden, deputy, or county clerk.

Bag and possession limits: 10 squirrels a day, 10 quail a day, 50 a season; 10 ducks a day, 50 a season, but not more than 5 of any one, or in the aggregate, of the following species—canvasback redhead, scaup, ringneck, teal, shoveler, and gadwall—a day; 4 geese, including brant, a day, 12 a season; 20 Wilson's snipe a day, 25 coots, 25 sora, and 25 in all of other rails and gallinules, but not more than 15 of any one species of rails (other than sora) and gallinules, 25 doves, and 4 woodcock a day. Not more than 2 days' bag limit of ducks and geese, including brant, and not more than 12 woodcock, may be possessed at any one time. Possession of game permitted during first 10 days of close season, and trophies or specimens of game lawfully taken may be possessed at any time.

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[15] *North Dakota:* Mondays and Tuesdays are rest days in the taking of pheasants.

[16] *Oklahoma:* Quail may not be hunted except on Monday, Wednesday, and Friday of each week during open season and on Thanksgiving Day and on Christmas and New Year's Days or the preceding Saturdays if these fall on Sundays.

Game taken outside of State and lawfully exported may be possessed in like manner as game taken in State.

Interstate transportation: Export prohibited of all protected game, but nonresident licensee may carry to his home 2 days' bag limit of game birds if license permit is attached.

Baiting: Doves may not be shot or otherwise taken by means of bait. Wild ducks, geese, and brant may not be taken on any baited premises except under seasonal permits issued by the Biological Survey.

OREGON

Open seasons:[17]	*Dates inclusive*
Deer (male, with forked horns)	Sept. 20–Oct. 25.
Bull elk, in parts of Umatilla, Baker, Union, Grant, and Wallowa Counties only	Nov. 5–Nov. 11
Bear, in Jackson, Josephine, and Klamath Counties	Nov. 1–Nov. 30.
In rest of State	No close season.
Silver-gray squirrel in Baker, Clatsop, Columbia, Coos, Crook, Curry, Gilliam, Grant, Jackson, Jefferson, Josephine, Klamath, Lincoln, Malheur, Morrow, Sherman, Tillamook, Umatilla, Union, Wallowa, and Wheeler Counties	Sept. 15–Oct. 20.
In Benton, Clackamas, Douglas, Lane, Linn, Marion, Polk, Washington, and Yamhill Counties	No close season.
Mountain or plumed, and California or valley, quail, in Yamhill, Marion, Wasco, Sherman, Gilliam, Morrow, Umatilla, Deschutes, Crook, Lake, Jackson, Josephine, Curry, Coos, and Douglas Counties	Oct. 15–Oct. 31.
In Klamath County	Oct. 1–Oct. 31.
In rest of State	No open season.
Bobwhite quail, in Malheur County	Nov. 1–Nov. 15.
In Benton and Polk Counties	Oct. 15–Oct. 31.
In rest of State	No open season.
Blue or sooty grouse, ruffed grouse or native pheasant, in Clatsop, Columbia, Tillamook, Washington, Multnomah, Clackamas, Yamhill, Lincoln, Polk, Marion, Linn, Benton, Lane, Douglas, Coos, Curry, Josephine and Jackson Counties	Oct. 15–Oct. 31.
In Sherman, Gilliam, Morrow, Umatilla, Wheeler, Jefferson, Deschutes, Crook, Klamath, Harney, and Malheur Counties, and sooty or blue grouse only in Grant County	Sept. 20–Oct. 25.
Open seasons—Continued.	*Dates inclusive*
Blue or sooty grouse—Continued.	
In Baker, Union, and Wallowa Counties	Aug. 20–Sept. 20.
Hungarian partridge, in Baker, Morrow, Sherman, Umatilla, Union, Wasco, and Wallowa Counties	Oct. 15–Oct. 31.
In Malheur County	Oct. 15–Nov. 15.
In rest of State	No open season.
Chinese pheasant (see exceptions)	Oct. 15–Oct. 31.
Exceptions: In Malheur County	Oct. 15–Nov. 15.
In Klamath County	Oct. 1–Oct. 31.
In Harney County (4 days)	Oct. 21, 24, 28, 31.
Duck (except wood duck, ruddy duck, and bufflehead), goose (except Ross's goose), brant, coot, Wilson's snipe or jacksnipe, Fridays, Saturdays, Sundays	Oct. 19–Dec. 23.
Rail and gallinule, except coot	Sept. 1–Nov. 30.

Hunting licenses: Nonresidents, $15. Alien, gun license, $25 (in addition to hunting license). Resident, game and fish, $5; game, $3. Hunting license (fee $1.50 issued to residents between 14 and 18 years of age), authorizes hunting in county of residence and adjoining counties. Issued by county clerks and authorized agents. Guide, $3 (issued only to citizens of United States).

Bag and possession limits: 2 black-tailed, 1 white-tailed or 1 mule deer a seaon; 5 silver-gray squirrels in 7 consecutive days; 10 quail in 7 consecutive days; 4 in all of ruffed grouse, pheasants, sooty or blue grouse, and Chinese pheasants a day, 8 in 7 consecutive days, but a bag of 8 shall not include more than 1 Chinese pheasant hen; 4 Hungarian partridges a day, 8 in 7 consecutive days; 15 in all of Wilson's snipe, rails, coots, and gallinules, a day 20 in 7 consecutive days; 12 ducks a day (but not more than 5 of any one, or in the aggregate, of the following species: eiders, canvasback, redhead, scaup, ringneck, teal, shoveler, and gadwall), 20 in 7 consecutive days; 4 geese, including brant, a day, but not more than 2 days' bag limit of ducks and geese, including brant, may be possessed at any one time. Game taken outside of State and legally exported may be imported and possessed as authorized by permit and tag (fee 5 cents) from State game warden, but migratory game birds, properly tagged, whether taken within or without the State, may be possessed only during first 10 days of close season.

Interstate transportation: Export of all protected game prohibited, except when tagged with metal seal and accompanied by permit from State warden showing kind of game and names and addresses of consignor and consignee, but not more than 2 days' bag limit of migratory game birds may be transported within one calendar week.

Baiting: Wild ducks, geese, and brant may not be taken on baited premises except under seasonal permits issued by the Biological Survey.

PENNSYLVANIA

Open seasons:	*Dates inclusive*
Deer (male, with 2 or more points to 1 antler)	Dec. 1–Dec. 15.
Bear	No open season.
Raccoon (see exception)	Oct. 15–Dec. 15.
Exception: In Adams, Bedford, Berks, Bucks, Carbon, Chester, Cumberland, Dauphin, Delaware, Fayette, Franklin, Fulton Greene, Lancaster, Lebanon, Lehigh, Montgomery, Philadelphia, Washington, and York Counties	Nov. 1–Dec. 31.
Hare, rabbit, black, gray, and fox squirrel	Nov. 1–Nov. 30.
Red or pine squirrel	Nov. 1–Aug. 15.

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[17] *Oregon:* Unlawful to kill geese or other wild birds or animals at any time on islands or sand bars or within one-fourth mile of high-water line on Columbia River east of eastern entrance of Celilo Canal in Wasco County, and extending easterly along Columbia River to Oregon-Washington boundary in Umatilla County, or on islands and sand bars in Deschutes and John Day Rivers from Columbia River to point half a mile south of Oregon Trail highway bridges where the highway crosses said rivers, respectively.

Open seasons—Continued.	*Dates inclusive*
Wild turkey (see exception), quail, pheasant (except Reeves's pheasant), males only, ruffed grouse	Nov. 1–Nov. 30.[18]
Exception: Wild turkey in Berks, Bradford, Bucks, Carbon, Clearfield, Dauphin, Jefferson, Lackawanna, Lebanon, Lehigh, Luzerne, Lycoming, Monroe, Northampton, Pike, Schuylkill, Tioga, Wayne, and Wyoming Counties	No open season.
Woodcock	Oct. 15–Nov. 14.
Duck (except wood duck, ruddy duck, and bufflehead), goose (except Ross's and snow geese, and brant), coot, Wilson's snipe or jacksnipe, Thursdays, Fridays, Saturdays	Oct. 18–Dec. 22.
Rails and gallinules, other than coot	Sept. 1–Nov. 30.

Hunting licenses: Nonresident and alien (reciprocal), minimum, $15. Resident, $2. Issued by department of revenue or county treasurer. Taxidermist, $25. Resident aliens not permitted to hunt, or to possess dogs or firearms.

Bag and possession limits: 1 deer a day or season (6 to hunting party); 3 raccoons a day, 10 a season; 3 hares a day, 15 a season; 4 rabbits a day, 24 a season; 6 squirrels a day, 20 a season; 6 quail a day, 24 a season; 2 pheasants (except Reeves's pheasant) a day, 6 a season; 1 wild turkey a day or season; 2 ruffed grouse a day, 12 a season; 4 woodcock a day, 20 a season, 12 in possession; 20 Wilson's snipe a day; 12 ducks a day, 60 a season (but not more than 5 of any one, or in the aggregate, of the following species—eiders, canvasback, redhead, scaup, ringneck, teal, shoveler, and gadwall—may be taken in 1 day and not more than 2 days' limit may be possessed at one time); 4 geese a day, 30 a season, 8 in possession; 15 rails, 15 gallinules, 25 coot a day. Game other than migratory game birds may be possessed during first 30 days of close season, migratory game birds first 10 days.

Game taken outside of State and legally exported may be possessed in like manner as game taken in State.

Interstate transportation: Export of all protected game taken in State prohibited; provided a nonresident licensee may take out with him on same conveyance 2 days' limit of game, except elk, legally taken. Small game must be accompanied by owner and if concealed must be tagged to show name and address of owner, county where killed, and number of each species in package. Large game may be shipped by express when plainly marked to show name and address of owner and county in which killed. Specimens and trophies of game legally taken may be shipped by parcel post or otherwise to a licensed taxidermist for mounting, if marked to show contents, but no such shipments may be made to points outside the State without a permit. Skins of raccoons may be shipped out of State by parcel post or otherwise if package is marked to show contents.

Baiting: Wild ducks, and geese may not be taken on baited premises except under seasonal permits issued by the Biological Survey.

RHODE ISLAND

Open seasons:	*Dates inclusive*
Gray squirrel, hare, rabbit	Nov. 1–Dec. 31.
Quail or bobwhite, ruffed grouse or partridge, cock pheasant (see exception)	Nov. 1–Dec. 31.
Exception: Cock pheasants in town of New Shoreham (4 days only), Oct. 18, Nov. 1 and 15, and Dec. 6, and in town of Jamestown (2 days only), Nov. 6 and 13.	
Woodcock	Nov. 1–Nov. 10.
Duck (except wood duck, ruddy duck, and bufflehead), goose (except Ross's and snow geese and brant) coot, Wilson's snipe or jacksnipe, Fridays, Saturdays, Sundays	Nov. 2–Jan. 6.
Rail and gallinule, other than coot	Sept.. 1–Nov. 30.

Hunting licenses: Nonresident, $10.25. Alien, $15.25. Resident, $2.25. Issued by city and town clerks.

Bag and possession limits: 2 ruffed grouse or partridges, 3 cock pheasants (except 2 a day in towns of New Shoreham and Jamestown), 6 quail, 12 ducks (but not more than 5 of any one, or in the aggregate, of the following species—eiders, canvasback, redhead, scaup, ringneck, teal, shoveler, and gadwall), 4 geese, 4 woodcock, 15 Wilson's snipe, 15 coot, 15 rails, 25 in all of rails and gallinules a day, but not more than 15 of any one species of gallinules, and not more than 15 game birds of all kinds, of which not more than 8 may be wild geese or 12 woodcock, in possession at one time. Possession of waterfowl, coots, and gallinules permitted during first 10 days of close season.

Game taken outside of State and legally exported may be imported and possessed under permit from commissioners, except migratory game birds as above stated.

Interstate transportation: Export of all game prohibited; provided, a nonresident licensee may take out under his license 10 wild fowl (8 geese) or other birds in 1 calendar year if carried open to view.

Baiting: Wild ducks and geese may not be taken on baited premises except under seasonal permits issued by the Biological Survey.

SOUTH CAROLINA

Open seasons:	*Dates inclusive*
Deer (male) (see exceptions)	Aug. 15–Jan. 1.
Exceptions: In Greenville, Pickens, and Oconee Counties (1 day only)	Jan. 1, 1935.
In Bamberg, Chester, Edgefield, Lexington, Richland, and Saluda Counties, and within 2 miles of Salkehatchie River in Allendale County	No open season.
In Newberry and Spartanburg Counties	Nov. 29–Feb. 1.
Bear	No close season.
Raccoon, opossum, rabbit, squirrel (see exceptions)	Sept. 1–Mar. 1.
Exceptions: Raccoon, opossum, in Clarendon County	Oct. 1–Mar. 1.
Raccoon, opossum, rabbit, squirrel, in Newberry and Spartanburg Counties	Nov. 29–Feb. 1.
Rabbit, in Abbeville, Laurens and McCormick Counties	Nov. 29–Mar. 1.
Rabbit, in Hampton and Williamsburg Counties	No close season.
Squirrel, in Cherokee and Richland Counties	Oct. 1–Mar. 1.
Squirrel, in York County	Nov. 1–Mar. 1.
Wild turkey (gobbler), partridge (quail) (see exceptions)	Nov. 29–Mar. 1.
Exceptions: Turkey, in Greenville County (1 day)	Jan. 1, 1935.
Turkey, in Spartanburg County	Nov. 29–Feb. 1.
Quail, in Chester, Fairfield, Greenville, Lancaster, Newberry, Pickens, Spartanburg, and York Counties	Nov. 29–Feb. 1.
Quail, in Chesterfield, Edgefield, and Lexington Counties	Nov. 29–Feb. 15.

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[18] *Pennsylvania:* Wild turkeys, male pheasants, ruffed grouse, quail, may be taken only on Nov. 1, 2, 3, 5, 6, 7, 10, 12, 14, 17, 19, 21, 24, 26, 28, 29, 30.

Open seasons—Continued.	*Dates inclusive*
Blackbird	Nov. 29–Mar. 1.
Mourning Dove	Sept. 1–Sept. 30. Nov. 20–Jan. 31.
Woodcock	Dec. 1–Dec. 31.
Duck (except wood duck, ruddy duck, and bufflehead), goose (except Ross's and snow geese, and brant), coot, Wilson's snipe or jacksnipe, Thursdays, Fridays, and Saturdays	Nov. 8–Jan. 12.
Rails and gallinules, other than coot	Sept. 1–Nov. 30.

Hunting licenses: Nonresident, $15.25. Resident, $3.10 (State), $1.10 (county of residence). Issued by county game warden and agents.

Bag and possession limits: 5 deer, 20 wild turkeys, a season; 15 squirrels, 15 quail (partridge), 2 turkeys, 18 doves, 12 ducks (but not more than 5 of any one, or in the aggregate, of the following species—canvasback, redhead, scaup, ringneck, teal, shoveler and gadwall), 4 geese, 4 woodcock, 20 Wislon's snipe, 25 coots, 25 sora, and 25 in all of other rails and gallinules, but not more than 15 of any one species of rails (other than sora) and gallinules a day. Not more than 2 days' bag limit of ducks and geese and not more than 12 woodcock may be possessed at any one time. Possession of migratory game birds permitted during first 10 days of close season. Game taken outside of State and legally exported may be possessed in like manner as game taken in State.

Interstate transportation: Export of all resident nonmigratory game taken in State prohibited, except that a landowner or licensee may export under shipping tag from chief game warden of State 1 day's bag limit of resident nonmigratory game a week, if not for sale. Unlawful for any transportation company to receive for shipment out of the State any deer or other resident nonmigratory game unless duly tagged. Under Federal regulations not more than 2 days' limit of migratory birds (3 days' limit of woodcock) may be taken or shipped out of the State in any 1 calendar week. All packages containing migratory birds must be marked to show actual contents and names and addresses of consignor and consignee. No game may be removed from the State for sale.

Baiting: Mourning doves may not be shot or otherwise taken by means of bait. Wild ducks and geese may not be taken on baited premises except under seasonal permits issued by the Biological Survey.

SOUTH DAKOTA

Open seasons:	*Dates inclusive*
Deer (male, with 2 or more points to 1 antler), in Meade, Lawrence, Pennington, Custer, and Fall River Counties only	Nov. 1–Nov. 20.
Elk	Nov. 1–Nov. 20.
Rabbit, squirrel	No close season.
Grouse, west of the Missouri River	Sept. 27–Sept. 30.
In rest of State	No open season.
Male pheasant, east of Missouri River [19]	Oct. 21–Nov. 4.
West of Missouri River (see exception)	Oct. 21–Oct. 22.
Exception: In Butte County	Oct. 21–Oct. 25.
In Gregory and Tripp Counties	Oct. 21–Nov. 4.
In hill portions of Lawrence, Pennington, Custer, and Fall River Counties	No open season.
Duck (except wood duck, ruddy duck, and bufflehead), goose (except Ross's goose), brant, coot, Wilson's snipe or jacksnipe, Fridays, Saturdays, Sundays	Oct. 5–Dec. 9.
Rails and gallinules, other than coot	Sept. 16–Nov. 30.

Hunting licenses: Nonresident or alien, big game, $25; small game, $25. Resident, big game, $5; small game, $1. Special license, small game, $3 (authorizes shipment of 50 birds in State as specified in license). Issued by game and fish department and deputies, and county treasurers.

Bag and possession limits: 1 deer, 1 elk, a year. Not more than 15 game birds may be taken in any one day, of which not more than 4 may be grouse, 5 may be pheasants. Four geese, including brant, and 12 ducks may be taken in 1 day, but not more than 5 of any one, or in the aggregate, of the following species—canvasback, redhead, scaup, ringneck, teal, shoveler, and gadwall; 25 coot a day or in possession; 20 jacksnipe a day or in possession. Possession permitted for 5 days after close of season, but not more than 30 birds (2 days' limit of grouse and pheasant, and 2 days' limit of ducks and geese, including brant) may be possessed at one time. Game taken outside of State and legally exported may be possessed in like manner as game taken in State.

Interstate transportation: Export of all protected game prohibited; provided, a nonresident may, under permit of the game and fish commission, export 1 deer lawfully killed, and not more than 5 upland nonmigratory birds under each of 5 of the coupons, and not more than 5 migratory game birds under each of 5 of the coupons attached to his nonresident license; but not more than 8 geese, including brant, may be exported by one person in any one calendar week, and if exported by common carrier or as personal baggage tags attached to hunting license must be affixed to each shipment.

Baiting: Wild ducks, geese, and brant may not be taken on baited premises except under seasonal permits issued by the Biological Survey.

TENNESSEE

Open seasons:	*Dates inclusive*
Deer (male) (see exception)	Dec. 1–Dec. 10.
Exception: In Cheatham, Lewis, Perry, and Wayne Counties	No open season.
Rabbit (see exceptions)	Nov. 25–Jan. 31.
Exceptions: In Sullivan County	Nov. 15–Jan. 1.
In Cannon, Dickson, Hickman, Houston, and Humphries Counties	No close season.
In Carroll County	Dec. 15–Feb. 15.
Squirrel (see exceptions)	June 1–Dec. 31.
Exceptions: In Dyer County	July 1–Dec. 31.
In Johnson County	July 1–Dec. 1.
In Cannon County	No close season.
Quail, wild turkey (see exceptions)	Nov. 25–Jan. 31.
Exceptions: Quail in Johnson County	Nov. 1–Jan. 1.
Quail in Sullivan County	Nov. 15–Jan. 1.
Quail in Cocke County	No open season.
Wild turkey in Lewis County	No open season.
Pheasant (see exception)	No open season.
Exception In Johnson County	Nov. 1–Jan. 1.
Dove (see exceptions)	Sept. 1–Dec. 15.
Exceptions: In Jackson County	Nov. 1–Dec. 15.
In Cocke County	No open season.
Duck (except wood duck, ruddy duck, and bufflehead), goose (except Ross's goose), brant, coot, Wilson's snipe or jacksnipe, Thursdays, Fridays, Saturdays	Nov. 8–Jan. 12.
Rail, other than coot and gallinule	Sept. 1–Nov. 30.
Gallinule	Nov. 1–Nov. 30.

Hunting licenses: Nonresident,[20] $15 (may hunt on own land without license). Resident, State, $2 Not required of residents in Cannon, DeKalb, Hickman, Humphries, Smith, and Stewart Counties. Issued by county clerks. *Reelfoot Lake;* Guide or pusher, $1; issued to residents only.

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[19] *South Dakota:* East of the Missouri River pheasants may be shot only during the afternoon from Nov. 21 to Dec. 5.

[20] *Tennessee:* Nonresidents not permitted to hunt in Henderson and Hickman Counties except on own land.

Bag and possession limits: 1 deer, 3 wild turkeys, a season; 10 squirrel, 15 quail, and 15 of other game birds a day, but not more than 4 geese including brant, 12 ducks (but not more than 5 of any one, or in the aggregate, of the following species—canvasback, redhead, scaup, ringneck, teal, shoveler, and gadwall), 15 of any one species of rails (other than sora) and gallinules, a day. Not more than 2 days' bag limit of ducks and geese may be possessed at one time.

Reelfoot Lake: 12 ducks (see exception above as to ducks), 4 geese including brant, 20 Wilson's snipe, 20 in all of rails, coot, and gallinules, but not more than 15 of any one species of rails (other than sora) and gallinules, a day, but not more than 20 in all of game birds a day.

Game taken outside of State and lawfully exported may be possessed in like manner as game taken in State.

Interstate transportation: Export of all protected game prohibited; provided, nonresident licensee may take out of State, if carried openly, game birds legally killed by him, but not more than 2 days' limit of ducks and geese, including brant, 40 Wilson's snipe, 50 coots, 50 sora, 50 in all of rails and gallinules, but not more than 30 of any one species of rails (other than sora) and gallinules, and 36 doves may be exported by one person in any 1 calendar week.

Baiting: Doves may not be shot or otherwise taken by means of bait. Wild ducks, geese, and brant may not be taken on baited premises except under seasonal permits issued by the Biological Survey.

TEXAS

Open seasons:	*Dates inclusive*
Deer (male, with pronged horn) (see exceptions), bear	Nov. 16–Dec. 31.
Exceptions: Black-tailed deer (male) west of Pecos River	Nov. 16–Nov. 30.
Deer, in Anderson, Archer, Bastrop, Bowie, Brown, Burnet (north of Colorado River), Callahan, Camp, Cass, Clay, Coleman, Coryell, Erath, Eastland, Freestone, Galveston, Haskell, Hamilton, Harrison, Hemphill, Henderson, Hutchinson, Jack, Jasper, Jones, Lamar, Lampasas, Leon, Limestone, Marion, Montague, Morris, Navarro, Newton, Palo Pinto, Panola, Parker, Red River, Roberts, Sabine, San Augustine, San Saba, Shackelford, Stephens, Throckmorton, Titus, Upshur, Wise, Wood, and Young Counties	No open season.
Squirrel (see exceptions)	May 1–July 31, Oct. 1–Dec. 31.
Exceptions: In Polk, Trinity, Nacogdoches, and Shelby Counties	Nov. 1–Jan. 31,
In Jefferson County	June 1–July 31, Nov. 1–Jan. 31.
In Jasper, Newton, and Young Counties	Nov. 10–Jan. 10.
In Hardin and Liberty Counties	June 1–June 30, Nov. 16–Jan. 16.
In Sabine and San Augustine Counties	Nov. 1–Dec. 31.
In Angelina and Tyler Counties	July 1–July 31, Oct. 1–Dec. 31.
In Panola County	July 1–July 31, Nov. 1–Dec. 31.
In Austin, Bandera, Bastrop, Blanco, Bosque, Brazoria, Brown, Burnet, Caldwell, Callahan, Colorado, Coleman, Comal, Comanche, Cooke, Coryell, DeWitt, Dimmit, Eastland, Edwards, Erath, Fayette, Fort Bend, Gillespie, Goliad, Gonzales, Guadalupe, Hamilton, Hays, Hill, Jackson, Karnes, Kendall, Kerr, Kimball, Lampasas, Lavaca, Llano, Mason, Matagorda, McCulloch, Medina, Menard, Mills, Montague, Palo Pinto, Parker, Real, San Saba, Schleicher, Stephens, Tarrant, Throckmorton, Travis, Uvalde, Victoria, Waller, Washington, Wharton, Wilson, Wise, and Zavala Counties	No close season.
Quail or partridge, chachalaca or Mexican pheasant (see exceptions)	Dec. 1–Jan. 16
Exceptions: In Panola, Rusk, and Harrison Counties	Dec. 1–Jan. 31.
Quail, in Anderson, Andrews, Archer, Borden, Gaines, Glasscock, Howard, Stephens and Yoakum Counties, and part of Karnes County	No open season.
Pheasant, in Comal, Erath, Gonzales, Guadalupe, and Wilson Counties	No open season.
Prairie chicken or pinnated grouse (see exception)	Sept. 1–Sept. 4.
Exception: In Collingsworth and Wheeler Counties	No open season.
Wild turkey gobblers (see exceptions)	Nov. 16–Dec. 31.
Exceptions: In Angelina, Bastrop, Brazos, Burleson, Cherokee, Grimes, Harris, Houston, Jasper, Lee, Leon, Madison, Montgomery, Nacogdoches, Newton, Polk, Robertson, Sabine, San Augustine, San Jacinto, Trinity, Tyler, Walker, and Washington Counties	Mar. 1–Apr. 30.
In Bowie, Callahan, Camp, Cass, Comal, Eastland, Erath, Freestone, Guadalupe, Gonzales, Harrison, Hardin, Lamar, Lampasas, Leon, Liberty, Limestone, Marion, Morris, Palo Pinto, Panola, Red River, San Saba, Shackelford, Stephens, Titus, Upshur, Wilson, and Wood Counties, and in Burnet County north of Colorado River	No open season.
Mourning dove, in north zone (except in Howard County, no open season)	Sept. 1–Oct. 31.[31]
In south zone (except in Brazos County, Nov. 15–Jan. 15)	Oct. 1–Nov. 30.[31]
White-winged dove, in north zone	Aug. 8–Oct. 31.[32]
In south zone	Aug. 20–Oct. 31.[32]

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[31] *Texas:* North and south zones divided by line running approximately northeast from Rio Grande near Del Rio, following Southern Pacific R.R. to San Antonio; International & Great Northern R. R. to Austin; Houston & Texas Central R. R. to Brazos River; Brazos River to Beaumont Branch of Santa Fe Ry.; Gulf, Colorado & Santa Fe R. R. to Cleveland, and Houston East & West Texas R. R. to Louisiana line.

[32] Zones for white-winged doves are divided by Texas-Mexican Ry. from Laredo to Corpus Christi.

Open seasons—Continued	*Dates inclusive*
Duck (except wood duck, ruddy duck, and bufflehead), goose, (except Ross's goose), brant, coot, Wilson's snipe or jacksnipe, Fridays, Saturdays, and Sundays	Oct. 26–Dec. 30.[23]
Rail and gallinule, other than coot	Sept. 1–Oct. 31

Hunting licenses: Nonresident or alien, $25. Resident citizen, $2 (not required in county of residence). Issued by commission, deputies, and county clerks. Boat (carrying hunters), $2; club or shooting preserve, $5. Issued by commission.

Bag and possession limits: 2 deer (west of Pecos River, 1 blacktail); 1 bear; 3 turkey gobblers a season; 10 squirrels a day; 12 in all of quail and chachalacas a day, 36 in 7 days, 36 of each in possession; in Wood County, 8 a day, 24 in 7 days; 10 prairie chickens a day or season; 15 doves and white-wings a day, 45 in 7 days or in possession; in Wood County, 10 a day, 40 in 7 days; 25 in all of ducks, rails, coots, gallinules, a day, but not more than 12 ducks a day (5 of any one, or in the aggregate, of the following species—canvasback, redhead, scaup, ringneck, teal, shoveler, and gadwall) nor more than 15 of any one species of rails (other than sora), and gallinules, a day, 50 in all in 7 days; 4 geese and brant combined a day, 12 in 7 days; 20 jacksnipe a day. Not more than 2 days' bag limit of ducks and geese, including brant, may be possessed at any one time. Possession of all game permitted during open season and 10 days immediately following. Game taken outside of State and legally exported may be possessed in like manner as game taken in State.

Interstate transportation: Export prohibited of all game, except that nonresident licensee may ship game lawfully possessed to his home for own use under affidavit (fee, 25 cents) that it was lawfully killed and will not be bartered or sold; provided that not more than 2 days' limit of migratory birds may be exported in any 1 calendar week. Game may be shipped to taxidermist for mounting under affidavit that shipper killed the specimen and that it is not being preserved for sale.

Baiting: Mourning doves may not be shot or otherwise taken by means of bait. Wild ducks, geese, and brant may not be taken on baited premises except under seasonal permits issued by the Biological Survey.

UTAH

Open seasons:[24]	*Dates inclusive*
Deer (male, with horns not less than 5 inches long)	Oct. 20–Oct. 30.
Elk	Nov. 8–Nov. 17.
Bear, rabbit, hare	No close season.
Duck (except wood duck, ruddy duck, and bufflehead), goose (except Ross' goose), brant, coot, Wilson's snipe or jacksnipe, Fridays, Saturdays, Sundays	Oct. 12–Dec. 16.
Rails and gallinules, other than coot	Sept. 1–Nov. 30.

Hunting licenses: Nonresident citizen—deer and bear, $15; elk, $50; small game and fish, $10. Resident citizen—male, 12 to 16 years old, game and fish $1; over 16 years, $3; game, $2; female, 16 and over, game and fish, $1; elk, $10. Guide, $5 (resident only). Issued by commissioner or deputy, and authorized agents. Alien not permitted to hunt or own firearms.

Bag and possession limits: 1 male deer a season; 25 in the aggregate of ducks, geese (including brant), coots, and Wilson's snipe a day, but not more than 12 ducks (5 of any one, or in the aggregate, of the following species—canvasback, redhead, scaup, ringneck, teal, shoveler, and gadwall), 4 geese (including brant), 25 coots or 15 Wilson's snipe a day, 25 in the aggregate of rails and gallinules, but not more than 15 of any one species. Not more than 2 days' bag limit of migratory game birds may be possessed at one time.

Game taken outside of State and legally exported may be possessed at any time, but migratory game birds may be possessed only during open season and first 10 days of close season. Persons possessing game during close season must show lawful taking.

Interstate transportation: Export of all game prohibited except under permit and regulations of commissioner.

Baiting: Mourning doves may not be shot or otherwise taken by means of bait. Wild ducks, geese, and brant may not be taken on baited premises except under seasonal permits issued by the Biological Survey.

VERMONT

Open seasons:	*Dates inclusive*
Deer (with horns not less than 3 inches long) (see exception)	Nov. 21–Nov. 30.
Exception: In Essex County	Nov. 1–Nov. 30.
Hare, rabbit	Oct. 1–Feb. 28.
Gray squirrel, woodcock, ruffed grouse	Oct. 1–Oct. 31.
Pheasant (8 days)	Oct. 3, 6, 10, 13, 17, 20, 24, 27, 31.
Quail	Sept. 15–Nov. 30.
Duck (except wood duck, ruddy duck, and bufflehead) (see exception), goose (except Ross's goose and brant), coot, English or Wilson's snipe (jacksnipe), gallinule, Fridays, Saturdays, Sundays	Oct. 5–Dec. 9.
Exception: Ducks on waters or shores of Joes Pond in towns of Danville, Cabot, and Walden; Stone Pond or Shadow Lake in town of Glover; Caspian Lake in town of Greensboro; and Groton or Lunds Pond in town of Groton (1937)	No open season.

Hunting licenses: Nonresident: Game, $10.50; but residents of States or countries charging larger nonresident angling license fee must pay fee charged nonresidents in own State or country. Resident: Game and fish, $1.50; game, $1. Issued by town clerks. Citizen of United States who owns $1,000 taxable property in Vermont pays same fees as resident. Alien resident who has not declared his intention pays same fees as nonresident; declarant resident for 6 months in State pays same fees as resident.

Bag and possession limits: 1 deer a season; 4 ruffed grouse a day, 25 a season; 4 woodcock a day, 25 a season, 12 in possession; 2 pheasants a day, 4 a season; 5 hares or rabbits a day or in possession; 4 gray squirrels a day or in possession; 4 quails a day, 10 ducks a day, 40 a season, but not more than 5 a day of any one, or in the aggregate, of the following species—eiders, canvasback, redhead, scaup, ringneck, teal, shoveler, and gadwall; 5 geese a season but not more than 4 a day; 10 Wilson's snipe a day; 25 coots; 25 gallinules, but not more than 15 gallinules of any one species a day.

Possession of waterfowl, coots, and gallinules permitted during first 10 days of close season, but not more than 24 ducks (10 of any one, or in the aggregate, of the following species—canvasback, redhead, scaup, ringneck, teal, shoveler, and gadwall), and 5 geese may be possessed at any one time.

Game taken outside of State and legally exported may be possessed as authorized by permit obtained from fish and game commissioner, except that migratory game birds may be possessed only during open season where taken and first 10 days of close season.

Interstate transportation: Export prohibited of all protected game, except hares and rabbits; provided, a nonresident licensee may export 1 deer under license coupon and 1 day's bag limit of game birds under permit, but must accompany shipment; resident may export (if not for sale) 1 day's bag limit of game birds under special permit from commissioner and 1 deer a season for sale, if it is tagged and license is presented to carrier for cancelation, but laws of State to which deer is shipped must be complied with. Packages containing game delivered to a common carrier for transportation must be tagged to show number and kind of such game therein, names of consignor and consignee, station from which shipped, destination, and number of license. License of shipper must be presented to agent of transportation company for indorsement thereon of quantity of game offered for transportation. Heads, hides, feet, and fur of quadrupeds and plumage and skins of game birds legally killed and possessed may be transported without tags if accompanied by owner.

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[23] Waterfowl may not be hunted or killed after 12 o'clock noon in Harrison and Marion Counties.

[24] *Utah:* Commissioner may fix open seasons and bag limits on upland game birds, and on mourning doves not to exceed season and bag limit fixed by Federal regulation.

Baiting: Wild ducks, geese, and brant may not be taken on baited premises except under seasonal permits issued by the Biological Survey.

VIRGINIA

Open seasons;	*Dates inclusive*
Deer (male, with horns visible above hair) (see exceptions)	Nov. 15–Dec. 31.
Exceptions: In Nansemond and Norfolk Counties	Oct. 1–Nov. 30.
In Accomac, Albemarle, Amherst, Arlington, Bedford, Campbell, Culpeper, Elizabeth City, Fairfax, Fauquier, Franklin, Greene, Henry, King George, Lancaster, Loudoun, Mathews, Madison, Nelson, Northampton, Northumberland, Orange, Patrick, Prince William, Princess Anne, Rappahannock, Richmond, Spottsylvania, Stafford, Warwick, Westmoreland, and York Counties, and west of Blue Ridge Mountains except in Alleghany, Bath, and Craig Counties	No open season.
In Craig County	Nov. 15–Nov. 30.
In Alleghany and Bath Counties	Nov. 15–Nov. 20.
Elk (with horns visible above hair) 3 days	Dec. 1, 3, 4.
Black bear (adult), east of Blue Ridge Mountains (see exception)	Nov. 15–Jan. 31.
Exception: In Nansemond and Norfolk Counties	Oct. 1–Nov. 30.
West of Blue Ridge Mountains	Nov. 15–Dec. 31.
Rabbit (see exceptions)	Nov. 15–Jan. 31.
Exceptions: In Accomac, Culpeper, Fairfax, Fauquier, Franklin, Loudoun, Northampton, Orange, Prince William, and Rappahannock Counties, and west of Blue Ridge Mountains	Nov. 15–Dec. 31.
In Bedford County	Nov. 15–Jan. 15.
Squirrel (see exceptions)	Sept. 1–Jan. 31.
Exceptions: In Albemarle, Amelia, Amherst, Arlington, Brunswick, Campbell, Charlotte, Cumberland, Dinwiddie, Elizabeth City, Essex, Fluvanna, Franklin, Goochland, Greene, Greensville, Halifax, Hanover, Henry, King and Queen, King William, Lancaster, Lunenburg, Madison, Mathews, Mecklenburg, Middlesex, Nelson, Northumberland, Nottoway, Pittsylvania, Powhatan, Prince George, Richmond, Spotsylvania, Stafford, Warwick, Westmoreland, and York Counties	Sept. 1–Sept. 30, Nov. 15–Jan. 31.
Open season—Continued	*Dates inclusive*
Squirrel—Continued.	
Exceptions—Continued.	
In Bland, Botetourt, Buchanan, Carroll, Clarke, Craig, Dickenson, Floyd, Giles, Grayson, Lee, Montgomery, Page, Pulaski, Roanoke, Rockbridge, Russell, Scott, Smyth, Tazewell, Warren, Washington, Wise, and Wythe Counties	Sept. 1–Dec. 31.
In Alleghany County	Sept. 1–Sept. 10, Nov. 15–Dec. 15.
In Bedford County	Sept. 1–Sept. 30, Nov. 15–Jan. 15.
In Appomattox, Buckingham, Caroline, Charles City, Chesterfield, Culpeper, Gloucester, Henrico, James City, King George, Louisa, and New Kent Counties	Nov. 15–Jan. 31.
In Bath and Highland Counties	Sept. 1–Sept. 10, Nov. 15–Nov. 30.
In Frederick County	Sept. 1–Oct. 15, Nov. 15–Dec. 31.
In Accomac and Northampton Counties	Oct. 1–Dec. 31.
In Augusta, Fairfax, Fauquier, Loudoun, Orange, Prince William, Rappahannock and Rockingham Counties	Sept. 1–Sept. 30, Nov. 15–Dec. 31.
In Isle of Wight, Nansemond, Norfolk and Princess Anne Counties	Oct. 1–Jan. 31.
In Shenandoah County	Sept. 1–Sept. 15, Nov. 15–Dec. 31.
Wild turkey, bobwhite quail, east of Blue Ridge Mountains (see exceptions)	Nov. 15–Jan. 31.
Exceptions: In Accomac, Culpeper, Fairfax, Fauquier, Loudoun, Northampton, Prince William, and Rappahannock Counties	Nov. 15–Dec. 31.
In Bedford County	Nov. 15–Jan. 15.
Turkey, in Albermarle County	Nov. 15–Nov. 30.
Turkey, in Essex, Lancaster, Northumberland, Richmond, and Westmoreland Counties	Nov. 15–Dec. 15.
Turkey, in Franklin, Patrick, and Henry Counties	No open season.
West of Blue Ridge Mountains (see exceptions)	Nov. 15–Dec. 31.
Exceptions: Turkey, in Bland, Buchanan, Carroll, Dickenson, Floyd, Giles, Grayson, Lee, Montgomery, Pulaski, Roanoke, Russell, Scott, Smyth, Tazewell, Washington, Wise, and Wythe Counties	No open season.
Turkey, in Alleghany County	Nov. 15–Dec. 15.
Turkey, in Bath and Highland Counties	Nov. 15–Nov. 30.
Quail, in Alleghany, Bath, and Highland Counties	Nov. 15–Dec. 15.
Quail, in Franklin County	Nov. 15–Dec. 31.
Ruffed grouse (see exceptions)	Nov. 15–Dec. 31.
Exceptions: In Alleghany County	Nov. 15–Dec. 15.
In Bath and Highland Counties	Nov. 15–Nov. 30.
East East of Blue Ridge Mountains, except in Bedford, Amherst, Nelson, Madison, and Greene Counties	No open season.

Open seasons—Continued.	*Dates inclusive*
Ruffled grouse—Continued.	
Exceptions—Continued.	
In Bedford, Amherst, Nelson, Madison, and Greene Counties	Nov. 15–Dec. 31.
Ringneck pheasant (see exceptions)	Nov. 15–Dec. 31.
Exceptions: In Augusta County (males)	Nov. 15–Nov. 24.
In Bedford and Rockingham Counties	No open season.
Mourning dove (see exceptions)	Sept. 1–Dec. 15.
Exceptions: In Accomac, Appomattox, and Northampton Counties	Nov. 15–Dec. 15.
In Louisa County	Sept. 1–Oct. 15. Nov. 15–Dec. 15.
Woodcock	Nov. 15–Dec. 15.
Duck (except wood duck, ruddy duck, and bufflehead), goose (except Ross's and snow geese, and brant), coot, (see exception) Thursdays, Fridays, and Saturdays	Nov. 8–Jan. 12.[21]
Exception: In Appomattox and Louisa Counties, Thursdays, Fridays, Saturdays	Nov. 15–Jan. 12.
Wilson's snipe or jacksnipe, Thursdays, Fridays, Saturdays	Nov. 15–Jan. 12.
Rails and gallinules (other than coot) (see exception)	Sept. 1–Nov. 30.
Exception: In Appomattox and Louisa Counties	Nov. 15–Nov. 30.

Hunting licenses: Nonresident (combined hunting and fishing), seasonal $15.50; one day only, except in Bland, Giles, and Tazewell Counties, $5. Additional county certificates required for bull elk in Bland, Craig, Giles, Montgomery, and Pulaski Counties, fee $1. Alien, hunting, $15.50. Resident: Statewide, $3; county, $1. Licenses issued by clerks of circuit and corporation courts and designated agents. Commissioned and enlisted personnel of Army, Navy, and Marine Corps stationed in Virginia, pay same fees for hunting as residents.

Special licenses, Back Bay, Princess Anne County: Battery, sinkbox, mat blind, fee $100 (limited to not more than 50 batteries and sinkboxes and 27 mat blinds actually used in 1927–28; any license not renewed each year may not be reissued until number of batteries and sinkboxes is less than 25 and that of mat blinds less than 11). Shore blind, $50. Issued by clerk, circuit court, Princess Anne County. Special license required for erection of blind in Lancaster, Northumberland, Prince George, Richmond, and Westmoreland Counties, $5.10; issued by circuit and county clerks and designated agents.

Bag and possession limits: 1 elk a season; 1 deer a day, 2 a season (in Alleghany, Bath, and Highland Counties, 1 a season) 2 bears a day or season; 10 each of squirrels and rabbits a day, 150 of each a season; 2 turkeys a day, 4 a season (2 a season in Rockbridge County); 4 grouse a day, 16 a season; 15 quail a day, 150 a season; 4 ringneck pheasants a day, 20 a season (in Augusta County 2 a day, 4 a season); 18 doves a day, 250 a season; 4 woodcock a day, 25 a season; 12 ducks a day (but not more than 5 of any one, or in the aggregate, of the following species—eiders, canvasback, redhead, scaup, ringneck, teal, shoveler, and gadwall), 350 a season; 4 geese a day, 50 a season; 20 Wilson's snipe a day, 250 a season; 25 sora a day, 500 a season; 25 coots a day, 250 a season; 25 in all of rails and gallinules (other than sora) a day, but not more than 15 of any one species, 250 a season. Possession permitted during first 10 days of close season, but not more than 2 days' bag limit of ducks and geese and not more than 12 woodcock may be possessed at one time.

Game taken outside of State and legally exported may be possessed in like manner as game taken in State.

Interstate transportation: Export of all protected game (except rabbits, squirrels, and bear) prohibited; provided, during open season any licensee may, under his hunting license, take with him out of State, or as baggage on same conveyance, open to view, and plainly labeled with his name and address, not more than 2 days' limit of game lawfully taken by him. Any licensee may ship from State during open season as a gift and not for sale (which fact must be stated on shipping tag) 1 day's bag limit in 1 calendar week, if open to view and plainly labeled with names and addresses of donor and donee and number and kind of each so shipped.

Baiting: Doves may not be shot or otherwise taken by means of bait. Wild ducks and geese may not be taken on baited premises except under seasonal permits issued by the Biological Survey.

WASHINGTON

Open seasons:	*Dates inclusive*
Deer (male, with branched horns), in western Washington	Oct. 1–Oct. 15.
In Asotin, Columbia, Garfield, Kittitas, Klickitat, Walla Walla, and Yakima Counties, and that part of Skamania east of Wind River and summit of Cascade Mountains	Oct. 14–Oct. 28.
In Chelan, Ferry, Okanogan, Pend Oreille, Spokane, and Stevens Counties	Oct. 28–Nov. 11.
In Adams, Benton, Douglas, Franklin, Grant, Lincoln, and Whitman Counties	No open season.
Elk (see exception)	No open season.
Exception: In Asotin, Columbia, Garfield, Kittitas, Walla Walla, and Yakima Counties (bulls only)	Nov. 1–Nov. 11.
Bear, in western Washington	Oct. 1–Oct. 15.
In Asotin, Columbia, Garfield, Kittitas, Klickitat, Walla Walla, and Yakima Counties, and Skamania County east of Wind River and summit of Cascade Mountains	Oct. 14–Oct. 28.
In Chelan, Ferry, Okanogan, Pend Oreille, Spokane, and Stevens Counties	Oct. 28–Nov. 11.
In Adams, Benton, Douglas, Franklin, Grant, Lincoln, and Whitman Counties	No open season.
Rabbits, throughout State	Oct. 1–Feb. 28.
Squirrels (see exception)	No open season.
Exception: In Clallam, Jefferson, Pierce, and Thurston Counties	Oct. 1–Oct. 31.
Blue grouse, in western Washington except island of San Juan	Sept. 16, 19, 22, 23.
Blue grouse, ruffed grouse, in eastern Washington, in Asotin, Columbia, Garfield, Pend Oreille, and Walla Wall Counties only	Sept. 16, 19, 22, 23.
Chinese pheasant, in western Washington (see exceptions)	Oct. 7, 10, 13, 14, 17, 20, 21, and 24.
Exceptions: In Island County	Oct. 7, 10, 13, 14, 17.
In Clallam County	No open season.
Chinese pheasant, in eastern Washington (see exception)	Oct. 21, 24, 27, 28, 31, Nov. 3, 4, 7.
Exception: In Pend Oreille County	No open season.

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[21] *Virginia:* On Back Bay, in Princess Anne County, battery, sinkbox, mat blind, or other floating device, or any boat or tender thereof, may not anchor, tie-out, or lie within 700 yards (except in North Bay, 200 yards) of any licensed blind or any blind on shore not licensed that is at any time occupied by the owner, or member or guest of any club owning same, for shooting therefrom.

Open seasons—Continued.	*Dates inclusive*
Hungarian partridge, in western Washington	No open season.
In eastern Washington (see exceptions)	Oct. 21, 24, 27, 28, 31, Nov. 3, 4, 7.
Exceptions: In Asotin, Columbia, Garfield, and Walla Walla Counties	Oct. 21, 24, 27, 28, 31, Nov. 3, 4, 7, 8, 9, 10, 11, 12, 13, and 14.
In Chelan, Ferry, Okanogan, Pend Oreille, and Stevens	No open season.
Valley quail, in western Washington (see exceptions)	No open season.
Exceptions: In Island County	Oct. 7, 10, 13, 14, 17.
In Pierce County	Oct. 7, 10, 13, 14, 17, 20, 21, 24.
Valley quail, in eastern Washington (see exception)	Oct. 21, 24, 27, 28, 31, Nov. 3, 4, 7.
Exception: In Lincoln, Klickitat, and Whitman Counties	No open season.
Band-tailed pigeons	Oct. 16–Oct. 30.
Ducks (except wood duck, ruddy duck, and bufflehead), geese (except Ross's goose), brant, coot, Wilson's snipe or jacksnipe, Fridays, Saturdays, Sundays	Oct. 19–Dec. 23.[26]
Rails and gallinules, other than coot	Oct. 1–Nov. 30.

Hunting licenses: Nonresident citizen or declarant residing in State less than 6 months: State, $25 (applicant from adjoining State pays same fee charged by his State to resident of Washington); game birds, $15. Resident: State, $7.50; county, $1.50. Guide, $10. Resident special elk license (fee $5), issued to holder of State or county license; nonresident, $25, issued to holder of State license. Alien, hunting and fishing, $25 (issued only to holder of permit to carry firearms). Licenses issued by county auditors.

Bag and possession limits: 1 deer, 1 elk, 1 bear a season; 5 rabbits, 5 squirrels a day; 3 grouse, 3 Chinese or Mongolian pheasants, 8 quail, 5 Hungarian partridges a day; a person desiring to possess more than 1 day's limit of upland game birds may do so by having each day's kill tagged that day by a game warden, and such tagged birds may be possessed during close season. Tagging fee, 10 cents for each bird, animal, or fish; 10 band-tailed pigeons a day or in possession; 4 geese, including brant, 12 ducks a day (but not more than 5 of any one, or in the aggregate, of the following species: Eiders, canvasback, redhead, scaup, ringneck, teal, shoveler, and gadwall), 20 jacksnipe, 25 coots, 25 sora, and 25 in all of other rails (except sora), but not more than 15 of any one species of rails (except sora) a day. Not more than 2 days' bag limit of wild ducks and wild geese including brant may be possessed at one time.

Possession during close season permitted upon filing with commission description and number of each kind of game, which must be tagged or stamped by commission for identification, but rails may only be possessed until December 10, and other migratory birds for 10 days after close of open season.

Game taken outside of State when accompanied by affidavit of chief game official may be possessed at any time for noncommercial use, except that migratory game birds may be possessed only during open season where taken and first 10 days of close season.

Interstate transportation: Export of all protected game prohibited, except that nonresident licensee may carry with him 1 day's limit of game birds upon attaching an affidavit that they were lawfully killed by himself and are not being exported for sale.

Baiting: Wild ducks, geese, and brant may not be taken on baited premises except under seasonal permits issued by the Biological Survey.

WEST VIRGINIA

Open seasons:	*Dates inclusive*
Deer (male, with branched horns), in Grant, Greenbrier, Monongalia, Pocahontas, Preston, Randolph, and Tucker Counties	Nov. 12–Nov. 17.
In rest of State	No open season.
Bear	Nov. 18–Dec. 31.
Rabbit, varying hare	Nov. 15–Jan. 15.
Squirrel (see exception)	Sept. 24–Nov. 16.
Exception: In Brooke, Greenbrier, Hancock, Harrison, Marion, Marshall, Monongalia, Ohio, Pocahontas, Preston, Randolph, Tucker, Tyler, Upshur, Webster, and Wetzel Counties	Oct. 17–Dec. 9.
Raccoon, opossum	Nov. 1–Jan. 31.
Wild turkey (see exception)	No open season.
Exception: In Grant, Greenbrier, Hampshire, Hardy, Mineral, Morgan, Nicholas, Pendleton, Pocahontas, Preston, Randolph, Tucker, and Webster Counties	Oct. 17–Nov. 17
Ruffed grouse	Oct. 17–Dec. 15.
Quail	Nov. 15–Jan. 1.
Woodcock	Nov. 15–Dec. 15.
Duck (except wood duck, ruddy duck, and bufflehead), goose (except Ross's goose), brant, coot, Wilson's snipe or jacksnipe	Nov. 1–Nov. 30.
Rails and gallinules, other than coot	Sept. 1–Nov. 30.

Hunting licenses: Nonresident, $15; resident, State, $3; county of residence and adjoining counties, $1. Issued by county clerk. Aliens not permitted to hunt or possess firearms.

Bag and possession limits: 1 deer a season; 1 wild turkey a day, 1 a season; 6 rabbits a day, 40 a season, except rabbits killed on own premises; 2 varying hares a day, 10 a season; 5 squirrels a day, 30 a season; 8 quails a day, 48 a season; 3 ruffed grouse a day, 12 a season; 12 ducks (but not more than 5 of any one, or in the aggrgeate, of the following species—canvasback, redhead, scaup, ringneck, teal, shoveler and gadwall); 4 geese, including brant; 4 woodcock a day, 12 in possession; 20 Wilson's snipe; 25 coots; 25 sora; and 25 in all of other rails and gallinules, but not more than 15 of any one species of rails (other than sora) and gallinules a day. Not more than 2 days' limit of ducks and geese, including brant, may be possessed at any one time. Possession of migratory birds permitted during first 10 days of close season; other game legally taken may be possessed at any time.

Game taken outside of State and legally exported may be possessed at any time, except that migratory game birds may be possessed only during the open season where taken and first 10 days of close season.

Interstate transportation: Export prohibited of elk, deer, squirrels, quail, ruffed grouse (pheasant), wild turkeys, geese, brant, ducks, provided, a nonresident licensee may personally take with him out of the State, during any open season, 1 day's limit of game animals or birds lawfully taken by himself.

Baiting: Wild ducks, geese, and brant may not be taken on baited premises except under seasonal permits issued by the Biological Survey.

WISCONSIN

Open seasons:	*Dates inclusive*
Deer (male only), in Ashland, Barron, Bayfield, Burnett, Chippewa, Douglas, Eau Claire, Florence, Forest, Iron, Langlade, Lincoln, Marinette, Oconto, Oneida, Polk, Price, Rusk, Sawyer, Taylor, Vilas, and Washburn Counties	Nov. 24–Nov. 30.

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[26] *Washington:* No open season on waterfowl on Columbia or Snake Rivers or within a quarter of a mile of their shores in Benton, Columbia, Douglas, Franklin, Garfield, Grant, Kittitas, Klickitat, Walla Walla, Whitman, and Yakima Counties.

Open seasons—Continued.	*Dates inclusive*
Deer—Continued.	
In Columbia and Sauk Counties (bow and arrow only)	Nov. 24–Nov. 28.
In rest of State	No open season.
Bear, in Ashland, Burnett, Chippewa, Douglas, Eau Claire, Florence, Forest, Iron, Langlade, Marinette, Oconto, Rusk, Taylor, and Washburn Counties only	Nov. 24–Nov. 30.
Rabbit, hare, in Ashland, Barron, Bayfield, Burnett, Douglas, Florence, Forest, Iron, Langlade, Marinette, Oneida, Polk, Price, Rusk, Sawyer, Taylor, Vilas, and Washburn Counties	Sept. 29–Feb. 15.
In Buffalo, Chippewa, Dunn, Eau Claire, Lincoln, Marathon, Oconto, Pepin, Pierce, St. Croix, and Trempealeau Counties	Sept. 29–Jan. 1.
In Adams, Clark, Jackson, Juneau, La Crosse, Monroe, Portage, Richland, Sauk, Shawano, Vernon, Waupaca, and Wood Counties	Nov. 1–Feb. 1.
In Milwaukee County (hares), and in Columbia County (jack rabbits)	No open season.
In rest of State	Nov. 1–Jan. 1.
Squirrels (see exceptions)	No open season.
Exceptions: In Ashland Barron, Burnett, Chippewa, Dunn, Eau Claire, Forest, Marathon, Marinette, Oconto, Pepin, Pierce, Polk, Rusk, St. Croix, Taylor, and Washburn Counties	Sept. 29–Nov. 15.
In Adams, Buffalo, Clark, Columbia, Crawford, Dane, Dodge, Door, Grant, Green, Iowa, Jackson, Jefferson, Juneau, Kenosha, Kewaunee, La Crosse, Lafayette, Marquette, Monroe, Outagamie, Richland, Rock, Sauk, Shawano, Trempealeau, Vernon, Waukesha, Waupaca, Waushara, and Winnebago Counties	Oct. 13–Dec. 1.
Ruffed grouse (partridge), in Adams, Ashland, Barron, Bayfield, Buffalo, Chippewa, Clark, Dunn, Eau Claire, Forest, Green Lake, La Crosse, Langlade, Lincoln, Marathon, Marinette, Marquette, Oconto, Oneida, Outagamie, Pepin, Pierce, Portage, Price, Rusk, St. Croix, Sawyer, Shawano, Taylor, Trempealeau, Vilas, Washburn, Waupaca, and Waushara Counties	Sept. 29–Oct. 7.
In Calumet, Columbia, Crawford, Dane, Door, Jackson, Juneau, Kewaunee, Manitowoc, Monroe, Richland, Sauk, Sheboygan, Vernon, and Wood Counties	Sept. 29–Oct. 2.
In rest of State	No open season.
Prairie chicken (pinnated grouse), and sharp-tailed grouse, in Adams, Ashland, Barron, Bayfield, Burnett, Chippewa, Clark, Douglas, Dunn, Eau Claire, Florence, Forest, Green Lake, Iron, Langlade, Lincoln, Marathon, Marinette, Marquette, Oconto, Oneida, Outagamie, Pepin, Polk, Portage, Price, Rusk, St. Croix, Sawyer, Shawano, Taylor, Vilas, Washburn, Waupaca, and Waushara Counties	Sept. 29–Oct. 7.
In Calumet, Columbia, Dane, Jackson, Jefferson, Juneau, Monroe, Sauk, Sheboygan, and Wood Counties	Sept. 29–Oct. 2.
In rest of State	No open season.
Ring-neck, Mongolian, or mutant pheasants, in Barron, Buffalo, Burnett, Dunn, Eau Claire, Pierce, Pepin, Polk, St. Croix, Trempealeau, and Washburn Counties	Sept. 29–Oct. 7.
In Calumet, Columbia, Dane, Dodge, Douglas, Fond du Lac, Green, Green Lake, Jefferson, Kenosha, Marquette, Outagamie, Ozaukee, Racine, Rock, Rusk, Sauk, Sawyer, Sheboygan, Walworth, Washington, Waukesha, Waushara, and part of Waupaca Counties	Sept. 29–Oct. 2.
In rest of State	No open season.
Hungarian partridge (see exception)	No open season.
Exception: In Dane, Jefferson, Kenosha, Racine, Walworth, and Waukesha Counties	Sept. 29–Oct. 2.
Bobwhite quail (see exception)	No open season.
Exception: In Clark, Columbia, Crawford, Dane, Grant, Iowa, Juneau, La Crosse, Marathon, Marquette, Pepin, Richland, Sauk, Vernon, Waukesha, Waushara, and Wood Counties	Sept. 29–Oct. 2.
Woodcock (see exception)	No open season.
Exception: In Adams, Buffalo, Burnett, Clark, Columbia, Crawford, Dane, Dunn, Eau Claire, Green Lake, Iowa, Jackson, Juneau, Kenosha, La Crosse, Langlade, Manitowoc, Marathon, Marquette, Monroe, Oconto, Ozaukee, Pepin, Pierce, Rusk, St. Croix, Shawano, Sheboygan, Taylor, Vernon, Washburn, Washington, Waukesha, and Waushara Counties	Sept. 29–Oct. 15.
Duck (except wood duck, ruddy duck, and bufflehead), goose (except Ross's goose), brant, coot, Wilson's snipe or jacksnipe, rails, and gallinules, Wednesdays, Thursdays, Fridays, Saturdays, Sundays (see exception)	Oct. 3–Nov. 11.[27]
Exception: In Milwaukee County	No open season.

Hunting licenses: Nonresident, all game, $50; all game except deer, $25; 3 shipping coupons, $2 additional. Settler, hunting deer, $1 (deer tag $1); guide, $1. Issued by commission. Resident, $1 (deer tag $1 additional); issued by county clerks.

Bag and possession limits: [28] 1 male deer, 1 bear, a season; 5 squirrels, 5 rabbits, a day (except 10 in certain counties); 4 ruffed grouse, 4 prairie chickens, 4 sharp-tailed grouse, 4 Hungarian partridges,

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[27] *Wisconsin:* Waterfowl may not be shot after 4 p. m. in certain counties.

[28] Mixed daily bag limit of upland birds not to exceed 4 in the aggregate, but not more than 2 cock pheasants; mixed possession limit, 8 birds, but not more than 4 cock pheasants.

4 bobwhite quail, a day, 8 of each in possession; 2 male pheasants a day, 4 in possession; 4 woodcocks a day, 12 in possession; 4 geese, including brant, a day; 12 ducks (including coot, or mud hen) a day, but not more than 5 of any one, or in the aggregate, of the following species—canvasback, redhead, scaup, ringneck, teal, shoveler, and gadwall; Wilson's snipe, rails, rice hens (gallinules), 15 a day, but not more than 25 in all of rails and gallinules a day. Possession of tagged deer permitted at any time for personal use, but not more than 1 day's bag limit of game, except as above stated, may be possessed at one time, and possession of game by an unlicensed person or one not holding a scientific permit, prohibited at all times.

Game taken outside of State and legally exported may be possessed as authorized by permit from conservation commission, except that migratory game birds may be possessed only during open season where taken and first 10 days of close season.

Interstate transportation: Export of all protected game prohibited, except that nonresident licensee may transport, between November 21 and November 30, inclusive (1934), 1 deer duly tagged, if he accompanies shipment and may take in his personal possession, openly, a mixed bag of not more than 20 game birds legally killed, but not more than the bag limit for 1 day of any one variety.

Baiting: Wild ducks, geese, and brant may not be taken on baited premises except under seasonal permits issued by the Biological Survey.

WYOMING

Open seasons:	*Dates inclusive*
Elk (see exceptions)	No open season.
Exceptions: In Albany, Big Horn, Carbon, Hot Springs, Johnson, Sheridan, and Washakie Counties	Oct. 15–Oct. 31.
In Fremont, Park, and Teton Counties	Sept. 15–Nov. 30.
In Lincoln County	Oct. 15–Nov. 30.
In Sublette County	Oct. 1–Nov. 30.
Deer (male, with forked horns) (see exceptions)	Oct. 15–Oct. 31.
Exceptions: In Crook and Weston Counties	Oct. 20–Nov. 15.
In Park County	Sept. 15–Nov. 30.
In Sublette County	Oct. 1–Nov. 15.
In Sweetwater County	Oct. 14–Oct. 21.
In Teton County	Sept. 15–Nov. 15.
In Fremont, Goshen, Laramie, and Niobrara Counties	No open season.
Moose (see exceptions)	No open season.
Exceptions: In Fremont and Teton Counties	Sept. 15–Nov. 30.
In Lincoln County	Oct. 15–Oct. 31.
In Park County	Sept. 15–Nov. 15.
In Sublette County	Oct. 1–Nov. 30.
Mountain sheep (see exceptions)	No open season.
Exceptions: In Fremont County	Sept. 15–Nov. 30.
In Lincoln, Sublette, and Teton Counties	Oct. 15–Oct. 31.
In Park County	Sept. 15–Nov. 15.
Antelope (see exception)	No open season.
Exception: In Campbell, Carbon, Converse, Fremont, Natrona, Niobrara, Park, and Weston Counties	Sept. 5–Oct. 10.
Open season—Continued.	*Dates inclusive*
Pheasant (male) (see exceptions)	No open season.
Exceptions: In Big Horn, Hot Springs, Park, and Washakie Counties	Nov. 5–Nov. 12.
In Fremont, Goshen, and Platte Counties	Nov. 4–Nov. 11.
In Sheridan County	Oct. 15–Nov. 15.
Grouse (see exceptions)	No open season.
Exceptions: In Campbell, Crook, Fremont, Sweetwater, Uinta, and Weston Counties	Sept. 1–Oct. 1.
In Johnson, Niobrara, Park, and Sheridan Counties	Sept. 15–Oct. 1.
Duck (except wood duck, ruddy duck, and bufflehead), goose (except Ross' goose), brant, coot, Wilson's snipe or jacksnipe, Wednesdays, Thursdays, Fridays, Saturdays, Sundays	Oct. 3–Nov. 11.
Rail and gallinule, other than coot	Sept. 16–Nov. 30.

Hunting licenses: Nonresident: General, $50; game birds only, $10; special bear permit (authorizes taking of 3 bears), $25. Resident: Big game, $5; game birds, $2. Guide license (citizen only), $5 (bond, $500). Permits to photograph birds and animals during January, February, March, and April, under supervision of commission, $5. Hunting predatory animals or bears in national forests, fee $1 for each dog. Licenses and permits issued by State game and fish commissioner, his chief assistant, chief clerk, assistant, and deputy game and fish commissioners, superintendents of fish hatcheries, justices of the peace, and persons authorized by State game and fish commission.

Bag and possession limits: 1 deer, 1 elk, 1 mountain sheep, 1 antelope, 1 bull moose, a season; 3 pheasant, 6 grouse a day. Federal limits on killing migratory game birds: 12 ducks (but no more than 5 of any one, or in the aggregate, of the following species—canvasback, redhead, scaup, ringneck, teal, shoveler, and gadwall), 4 geese, including brant, 20 Wilson's snipe, or jacksnipe, 25 coots, a day. Not more than 2 days' limit of ducks and geese, including brant, may be possessed at any one time.

Game taken outside of State and legally exported may be possessed at any time, except that migratory game birds may be possessed only during open season where taken and first 10 days of close season. Person possessing game during close season in State must show lawful taking.

Interstate transportation: Export of all protected game prohibited, provided, game may be exported if properly tagged by a justice of peace, assistant or deputy commissioners, or superintendents of fish hatcheries; fee, 50 cents. Game tags issued under affidavit that game was lawfully killed, and, if for edible portion, that it is not for sale. Not more than 2 days' bag limit of migratory game birds may be exported by one person in 1 calendar week.

Baiting: Wild ducks, geese, and brant may not be taken on baited premises except under seasonal permits issued by the Biological Survey.

LAWS OF CANADA

ALBERTA

Open seasons:	*Dates inclusive*
Deer, moose, caribou (must have horns at least 4 inches long)	Nov. 1–Dec. 14.[20]
Mountain sheep (male), mountain goat (must have horns at least 4 inches long)	Sept. 1–Oct. 31.[20]
Bear (except cubs or bear with cubs)	Sept. 1–June 14.[20]
Sharp-tailed grouse, north of Canadian Pacific Railway and Red Deer River	Oct. 1–Oct. 31.
In rest of Province	Oct. 1–Oct. 15.

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[20] *Alberta:* Deer, moose, and caribou, open season under special license in Rocky Mountain Forest Reserves of Alberta, Sept. 1 to Oct. 31, inclusive (see *Hunting licenses*). Hunting of big game prohibited south of Saskatchewan River and east of Canadian Pacific Railway from Edmonton, Calgary, and McLeod. Moose protected south of Canadian Pacific Railway from Calgary to Banff.

Open seasons—Continued.	*Dates inclusive*
Grouse, blue grouse, spruce partridge, north of Canadian Pacific Railway and Red Deer River only	Oct. 1–Oct. 15.
European gray partridge (Hungarian partridge)	Sept. 15–Dec. 15.
Duck, goose, Wilson's snipe or jacksnipe, coot, rails:	
North of Clearwater and Athabaska Rivers	Sept. 1–Nov. 14.
South of these rivers	Sept. 15–Nov. 14.

Hunting licenses: Nonresident: General, $50; elk license, $50; game bird, $25. Resident: Big game, $2; special big game, $5; special elk, $10; bird, $2.50. Guide, $2.50 (guide may not act for more than three persons on any trip). Special license: Nonresident, $50; resident, $5 (issued to holders of general licenses and authorizes taking of deer, moose, and caribou in Rocky Mountain Forest Reserve of Alberta, north of North Saskatchewan River, Sept. 1 to Oct. 31, inclusive). Taxidermist, $5. Issued by minister of agriculture.

Bag and possession limits: Deer, moose, caribou, elk, mountain sheep, mountain goat, bear, 1 of each species a season; sharp-tailed grouse, 5 a day, 50 a season north of Canadian Pacific Railway; 5 a day, 25 a season south of said railway; Hungarian partridges, 15 a day, 200 a season; grouse, blue grouse, spruce partridge, 5 in aggregate a day, 25 a season; 15 ducks a day during September, 25 a day rest of season, 100 a season; 10 geese a day, 25 a season; 25 coots, 25 rails, 25 Wilson's snipe a day. Migratory game birds legally taken during the open season may be possessed until March 31.

Export: Export of all protected game prohibited, except that minister of agriculture may grant permits for export of game at rate of $5 for each head of big game and $1 a dozen for game birds. The holder of a general nonresident license may export, as trophies, heads, skins, and hoofs of big game legally killed by him. Any person may export mounted or branded heads at a fee of $1 a head. Export of migratory birds prohibited during close season.

Miscellaneous: Use of live decoys in hunting migratory waterfowl prohibited.

BRITISH COLUMBIA

Open seasons: [30]	*Dates inclusive*
Bull moose, in Atlin, Fort George, Cariboo, and Omineca electoral districts; that part of Skeena district lying in eastern district; and Kamloops electoral district north of fifty-first parallel	Sept. 1–Dec. 15.
In Fernie and Columbia electoral districts (except south of Bugaboo Creek and west of Columbia River in Columbia electoral district)	Sept. 15–Oct. 31.
Bull caribou, in eastern district [30] except in Mackenzie and Skeena electoral districts, Cariboo electoral district west of Fraser River, and except south of main line Canadian Pacific Railway	Sept. 1–Dec. 15.
South of Canadian Pacific Railway	Sept. 15–Sept. 30.
Bull elk (wapiti) in Fernie and Columbia electoral districts (except west of Columbia River in Columbia electoral district)	Sept. 15–Oct. 15.
Male mountain sheep, in eastern district north of Canadian National Railway and in Cariboo and Lillooet electoral districts south of the main Chilcotin River, and west of Fraser River, and in Fernie, Cranbrook, and Columbia electoral districts	Sept. 1–Nov. 15.
Mountain goat in eastern district (except North and south Okanagan, and Grand Forks-Greenwood electoral districts)	Sept. 1–Dec. 15.
In western district [31] (except Vancouver Island)	Sept. 16–Dec. 15.
In rest of Province	No open season.
Male deer (mule, white-tail, coast) in eastern district [30] (see exceptions)	Sept. 15–Dec. 15.
Exceptions: White-tailed deer in North and South Okanagan and Similkameen electoral districts and west of summit of Midway Mountains in Grand Forks-Greenwood electoral district	No open season.
In rest of eastern district south of Canadian Pacific Railway (does only)	Dec. 1–Dec. 15
In western district [31] (except Mayne Island	Sept. 15–Nov. 30.
Does only in western district (except Mayne Island)	Dec. 1–Dec. 15.
Bear (except white or Kermodei bear) in eastern district [31]	Sept. 1–June 30.
In western district [31]	Sept. 16–June 30.
Band-tailed pigeon, in western district only	Sept. 8–Oct. 15.
Duck (except eider duck), goose, brant, coot, Wilson's snipe or jacksnipe, in eastern district [31] (see exceptions)	Sept. 15–Dec. 31.
Exceptions: In Creston, Nelson, and Kaslo-Slocan electoral districts	Sept. 15–Nov. 30.
In Omineca, Fort George, and Atlin electoral districts	Sept. 1–Dec. 15.
Duck (except eider duck), goose, coot, Wilson's snipe, in western district [31]	Oct. 13–Jan. 29.
Black brant, in western district, including Atlin electoral district south of fifty-sixth parallel [31]	Nov. 15–Feb. 28.

Hunting licenses: Nonresident: General, $25, and $25 additional for each grizzly bear, moose, mountain sheep, wapiti, or caribou, $15 additional for each black or brown bear, mountain goat, or mule deer, and $5 additional for every deer of any other species shot by him; British subject, birds $5 a week. Resident British subjects or farmers as defined under game act, and members of army, navy, air forces, or militia on duty in Province: Deer and birds, $2.50; big game and birds, $5. Big game, birds, and trapping, $10; resident alien, $10 (big game and game birds only); guide, $5; taxidermist, $5. Issued by warden or any person authorized by him.

Bag and possession limits: [31] 1 moose, 2 caribou (except in eastern district south Canadian National Railway, limit 1), 1 elk (wapiti), 2 mountain sheep

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[30] *British Columbia:* Regulations prescribing seasons, bag limits, and restrictions on sale of upland game birds for season 1934–35 are adopted by lieutenant governor in council. Full information may be had from provincial game commissioner, Vancouver.

[31] *Western district* includes that portion of Province west of summit of Cascades and south of Atlin electoral district, and, in the case of migratory birds, excluding that portion of Lillooet electoral district east of the easterly railway yard limit of Alta Lake railway station on Pacific Great Eastern Railway, and that portion of Skeena electoral district east of easterly railway yard limit of Shames on Canadian National Railway, bounded on the north by Atlin electoral district and on the south by Maitland Island and that part of Atlin electoral district south of fifty-sixth parallel and west of summit of Cascade Mountains. *Eastern district* includes rest of Province.

(except in Fernie, Cranbook, Columbia electoral districts, and in Cariboo and Lillooet electoral districts, south of main Chilcotin River and west of Fraser River, limit 1), 2 mountain goats, 3 deer, 2 grizzly bears, 3 bears of any other species a season; 10 band-tailed pigeons a day, 50 a season; 20 ducks a day, 150 a season; 10 geese a day, 50 a season; 10 brant a day, 50 a season; 25 Wilson's snipe a day, 150 a season; 25 coots a day, 150 a season. (Limits on other species of game fixed by regulations of lieutenant governor in council.) Game may be possessed for 2 weeks after close of open season.

Export: Export of all game prohibited except under permit of provincial game warden.

MANITOBA

Open seasons:	*Dates inclusive*
Male caribou, moose, or reindeer, deer north of fifty-third parallel	Nov. 15–Dec. 5.
South of fifty-third parallel	Sept. 25–Oct. 15. Nov. 15–Dec. 5.
Prairie chicken, Hungarian partridge, ruffed grouse	Oct. 5, 6, 8, 9, 10.
Ptarmigan	Oct. 1–Oct. 20
Duck, goose, coot, rails, north of fifty-third parallel	Sept. 1–Nov. 30
South of fifty-third parallel	Sept. 20–Nov. 15
Wilson's snipe or jacksnipe	Sept. 15–Nov. 30.

Hunting licenses: Nonresident alien, big game, $40; birds, $25. Nonresident British, big game, $25; birds, $10. Resident, big game, $5; birds, $2. Issued by director of game and fisheries, department of mines and natural resources. License to hunt deer not issued after November 30.

Bag and possession limits: 1 in all of deer, moose, and caribou a season; 10 in all of prairie chicken, grouse, and Hungarian partridge; 15 ptarmigans a day, 50 a season; 15 ducks a day in September, 25 a day in October and November, 100 a season; 40 in possession; 10 geese a day, 50 a season; 25 coots and rails, and 25 Wilson's snipe a day. Possession of ptarmigans allowed for 10 days after close of hunting season and of migratory game birds until March 31, but south of the fifty-third parallel the possession of more than 50 ducks or 15 geese is unlawful. Venison for private use may be possessed at any time on proof of legal killing. Heads and hides of big game legally taken within or without Province may be possessed at any time.

Export: Export prohibited of all protected game, except under permit issued by department of mines and natural resources. No permit may be issued for export of ptarmigans, geese, ducks, or entire carcass of any moose, caribou, or deer; provided, nonresident licensee under permit issued free may export carcass of moose, caribou, or deer, and not more than 10 geese and 50 ducks killed by him. Export of migratory birds prohibited during close season.

NEW BRUNSWICK

Open seasons:	*Dates inclusive*
Deer (see exception)	Sept. 15–Nov. 30.
Exception: On Grand Manan group, Campobello, and Deer Islands	Oct. 15–Nov. 15.[32]
Bull moose (antlers must have 6 points)	Oct. 20–Nov. 20.
Partridge	No open season.
Duck (except wood duck), goose, brant, rail, coot, (see exception)	Sept. 15–Dec. 31.
Exception: Islands in Grand Manan group	Oct. 15–Jan. 31.
Woodcock, jacksnipe, or Wilson's snipe (see exception)	Oct. 1–Nov. 30.
Exception: Islands in Grand Manan group	Oct· 15–Nov. 30.

Hunting licenses: Nonresident: Big game, $50 (1 bull moose, 2 deer, 4 bears and ducks); $25 (2 deer, 4 bears and ducks), special license, $25 (4 bears, April 1–June 30); bird $25. Resident: Big game, $3 (1 bull moose, 2 deer); $2 (2 deer); bird, $1; taxidermist, $1; guide, $1; camp help, $1.

Bag and possession limits: 2 deer, 1 moose (lumber camp limited to 2 moose and 4 deer) a season; 15 ducks a day, 150 a season; 15 geese, 15 brant, 25 in all of rails, coots, gallinules, and 25 Wilson's snipe a day; 8 woodcock a day, 125 a season. Game may be kept for personal use in cold storage during close season under permit, but migratory game birds may not be possessed after January 31, except in Grand Manan group they may be possessed until the last day of February.

Export: Export of all game prohibited, except game killed by nonresident licensee may be exported within 15 days after being killed, under permit from Canadian customs office.

NORTHWEST TERRITORIES [33]

Open seasons:	*Dates inclusive*
Deer, moose, and mountain goat	Sept. 1–Mar. 31.
Mountain sheep, caribou	Sept. 1–Feb. 28.
Partridge, prairie chicken, ptarmigan, and other grouse	Sept. 1–Dec. 31.
Duck, geese, brant, rail, coot, gallinule, Wilson's snipe	Sept. 1–Dec. 14.

Hunting and trapping licenses: Restricted to holders of licenses in 1933. Nonresident British, $75; other nonresidents, $150. Residents, $2. Trading licenses, nonresident British, $150; other nonresidents, $300; residents, $5. Issued by Commissioner of Northwest Territories. Permit from Commissioner required to establish trading post.

Bag and possession limits: 25 ducks, 15 geese, 15 brant, 25 in all of rails, coots, and gallinules, and 25 Wilson's snipe a day. Migratory game birds legally taken during open season may be possessed until April 14.

Export: Export of the meat or the raw skins of game animals prohibited, except under permit from minister or authorized officer.

NOVA SCOTIA

Open seasons:	*Dates inclusive*
Bull moose (except on Cape Breton Island, no open season), buck deer	Oct. 10–Oct. 31.
Hare, rabbit (see exception)	Nov. 15–Feb. 28.
Exception: On Cape Breton Island	Nov. 1–Feb. 28.
Ruffed grouse	Oct. 15–Oct. 31.
Woodcock and Wilson's snipe or jacksnipe	Oct. 1–Nov. 30.
Duck (except wood duck), goose, brant, rail, coot (see exceptions)	Oct. 1–Jan. 15.
Exceptions: Goose, brant, in Shelburne and Queens Counties	Nov. 1–Jan. 31.
Duck, rail, in Colchester and Cumberland Counties	Sept. 15–Dec. 31.

Hunting licenses: Nonresident or alien: General, $50; special deer license, $25; birds and small game except woodcock and snipe, $15; woodcock and snipe, $25. Resident: Big game, $2; guide, $2. Taxidermist, $5. Issued by minister of lands and forests, and agents.

Bag and possession limits: 1 buck deer, 1 moose a season; 5 ruffed grouse a day; 10 ducks, 5 geese, 5 brant, 25 in all of rails and coots, 25 Wilson's snipe, a day; 8 woodcock a day, 125 a season. Green hide or fresh meat of moose and deer may be possessed

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[32] *New Brunswick:* Resident of Grand Manan, Campobello, and Deer Islands may procure license to shoot 1 deer, Oct. 15 to Nov. 15, and game birds other than partridge, fee $1.10.

[33] *Northwest Territories* means the northwest territories formerly known as Rupert's Land and the northwestern territory (except such portions thereof as are included in Provinces of Ontario, Quebec, Manitoba, Saskatchewan, and Alberta and Yukon Territory), together with all British territories and possessions in North America and all islands adjacent thereto not included within any Province, except Colony of Newfoundland and its dependencies.

October 16 to November 20. Migratory game birds legally taken may be possessed for 1 month after close of open season, except that geese may be possessed until last day of February in Shelburne and Queens Counties.

Export: Export of all protected game, except hare and rabbit, prohibited, but holder of nonresident general license or special deer license, may ship out of Province under license tag 1 moose or 1 deer lawfully shot by himself.

ONTARIO

Open seasons:	*Dates inclusive*
Deer, bull moose, north of main line Canadian National Railway, between Quebec and Manitoba boundary lines	Sept. 15–Nov. 25.
South of Canadian National Railway to Mattawa River and Canadian Pacific Railway to Heron Bay, north shore Lake Superior	Oct. 20–Nov. 25.
South Canadian Pacific Railway to Heron Bay and north Lake Nipissing and French River (see exception)	Nov. 1–Nov. 25.
Exception: On St. Joseph Island, Algoma district	Nov. 10–Nov. 25.
Deer, south of French and Mattawa Rivers (except deer in counties of Bruce, Grey, Simcoe, York, and south and west thereof, and in counties of Leeds, Grenville, Dundas, Stormont, Glengarry, and Carleton, no open season)	Nov. 5–Nov. 20.
Hare	No close season.
Woodcock	Sept. 15–Nov. 30.
Duck (except wood duck), goose, brant, Wilson's snipe or jacksnipe, rail, coot, gallinule, north and west of French and Mattawa Rivers and in all Georgian Bay waters (see exception)	Sept. 1–Dec. 15.
Exception: Eider duck north of Canadian National Railway from Quebec boundary to Manitoba line only	Sept. 1–Dec. 15.
Duck (except wood duck and eider duck) south of French and Mattawa Rivers, excluding Georgian waters	Sept. 15–Dec. 15.

Hunting licenses: Nonresident: Game, $41; game birds and rabbits, $21. Resident, moose, $6; deer, $4; camp license, $4 (allows 1 deer to 6 residents for food in camp); game, $1. Guide, $2. Issued by department of game and fisheries.

Bag and possession limits: 1 deer, 1 bull moose, a season; 15 ducks a day, 150 a season; 15 geese, 15 brant, 25 in all of rails, coots, and gallinules, and 25 Wilson's snipe a day. Eight woodcock a day, 125 a season. Two or more persons hunting together under license may kill an average of 1 deer each. Possession of all game legally taken permitted during open season and until March 31.

Export: Export of all wild game animals and birds prohibited, provided, 1 deer, 100 ducks, 1 bull moose, and under export permit bears or bear pelts, may be exported under nonresident hunting license if shipping coupon and, if required, affidavit of lawful killing be attached and contents of packages be open to view. Minister may issue permit for export of game, dead or alive, at any time, except migratory birds during close season.

PRINCE EDWARD ISLAND

Open seasons:	*Dates inclusive*
Hare, rabbit	Nov. 1–Feb. 1.
Partridge (open in odd, closed in even years)	Oct. 15–Nov. 15.
Woodcock, jacksnipe or Wilson's snipe	Sept. 15–Nov. 30.

Open seasons—Continued	*Dates inclusive*
Duck, goose, brant, rail, coot, gallinule	Sept. 1–Dec. 14.

Hunting licenses: Nonresident, $20; nonresident owner of real estate valued at $325 and paying taxes thereon, $5; sons, brothers, and sisters of residents returning for visit, $2.50; guest permit $2.25 per week. Issued by game inspector or justice of peace.

Bag and possession limits: 3 partridges a day; 10 ducks, 5 geese, 5 brant, 25 in all of rails, coots, and gallinules, and 25 Wilson's snipe a day; 8 woodcock a day, 125 a season. Migratory game birds legally taken in open season may be possessed until January 31.

Export: Export prohibited of all game, provided, nonresident licensee may carry out of Province 12 birds killed by himself if tagged and carried open to view. Export of migratory birds prohibited during close season.

QUEBEC

Open seasons:	*Dates inclusive*
Bull moose (see exception)	Sept. 10–Dec. 31.
Exception South of St. Lawrence River	Sept. 20–Dec. 31.
Deer	Sept. 1–Nov. 30.
Caribou, in Gaspe, Bonaventure, and Matane Counties only	Sept. 20–Dec. 31.
Hare	Oct. 15–Jan. 31.
Bear	Aug. 20–June 30.
Birch or spruce partridge, sharp-tailed grouse	Sept. 1–Dec. 15.
White partridge or ptarmigan	Nov. 1–Jan. 31.
Duck, goose, brant, rail, coot, gallinule, woodcock, Wilson's snipe or jacksnipe	Sept. 1–Dec. 15.

Hunting licenses: Nonresident: General, $25 (fee, $1) (members of incorporated hunting clubs, $10 plus fee of 50 cents). Resident, not British subject, $5, resident, deer, $1, moose, $1. Special caribou license: Residents, $1; nonresidents, $1, in addition to $25 license. Resident British subject not hunting for own use must obtain special license. Issued by Minister of Colonization.

Bag and possession limits: 2 deer, 1 moose, 1 caribou, a season; 25 ducks, 15 geese, 15 brant, 25 in all of rails, coots, and gallinules, and 25 Wilson's snipe a day; 8 woodcock a day, 125 a season. Migratory game birds legally taken during open season may be possessed until March 31, and others during first 15 days of close season.

Export: Export of moose, caribou, and deer, or parts thereof, prohibited, except nonresident licensee may take out game animals killed by himself, under customs declaration and approval of Canadian collector of customs; export of grouse or partridges and of migratory birds prohibited during close season. Big game lawfully taken and coming from without Province may be transported under export permit of Minister of Colonization.

SASKATCHEWAN

Open seasons:	*Dates inclusive*
Deer, moose (males only), caribou (see exception)	Nov. 15–Dec. 14.
Exception: South of Township 35	No open season.
Hungarian partridge	Sept. 15–Nov. 14.
Sharp-tailed grouse, or prairie chicken; pinnated grouse, or prairie hen, ruffed grouse	Oct. 1–Oct. 31.
Duck (except wood duck), goose, coot, Wilson's snipe or jacksnipe south of Township 61	Sept. 15–Nov. 14.
North of Township 60	Sept. 1–Oct. 31.

Hunting licenses: Nonresident alien: Big game, $50; birds, $25; nonresident domiciled in Canada: Big game, $25; birds, $10; issued by Minister of Railways, Labor, and Industries. Resident: Big game, $5; birds, $1.50; issued by minister or agent.

Bag and possession limits: 1 moose a season; 2 deer or 1 deer and 1 caribou, 1 caribou a season; 15 Hungarian partridges a day, 30 in possession; 5 of each species of grouse a day, 10 each in possession; 15 ducks, 5 geese, a day; 30 coots a day, 150 a season; 15 Wilson's snipe a day, but not more than 2 days' limit of each in possession at one time. Game birds may be kept in licensed storage from September 16 to last day of February, and flesh of big game from December 1 to April 1, if tagged with number and kind of game, name of depositor, and number of his hunting license.

Export: Export of all protected game prohibited; provided, nonresident licensee on leaving Province may take with him during open season personally under his license coupons and permit, big game and 100 game birds legally killed. Export of migratory birds prohibited during close season. Minister may issue permits to export deer (fee, $2 a head) or other big game (fee, $5 a head), hides of big game (fee, $1 each), flesh of big game (fee, $1 each 20 pounds or less); birds (fee, $1 a dozen; limits, 5 dozen ducks, 1 dozen geese, a season). No permit may be issued for the entire carcass of a moose, caribou, or other deer, and no person may export in one season more than 60 ducks or 12 geese.

YUKON

Open seasons: [34]	*Dates inclusive*
Deer, moose, caribou, mountain sheep, mountain goat (males only)	Aug. 1–Mar. 1.
Partridge, prairie chicken, grouse, ptarmigan, pheasant	Sept. 1–Mar. 15.

Open seasons—Continued	*Dates inclusive*
Duck, goose, brant, rail, coot, gallinule, Wilson's snipe or jacksnipe	Sept. 1–Dec. 14.

Hunting licenses: Nonresident, not British subject, $100; nonresident British subject, $75 (permits the killing of 1 moose, 2 deer, 2 caribou, 1 mountain sheep, and 1 mountain goat); licensee in addition may kill 1 moose, 2 deer, 2 caribou, 1 mountain sheep, and 1 mountain goat, but must pay a fee of $25 for each additional animal so taken. Nonresident, general game, $5. Resident, $25 (special license authorizing the killing of male moose and male caribou over 1 year of age at any time for food supplies in the Territory); licensee must make annual returns. Resident, general game, $1. Resident: Chief guide, $20; assistant guide, $10. Issued by commissioner or game guardian.

Bag and possession limits: (For limits on big game to a nonresident, see Hunting Licenses.) Six caribou, 6 deer, 2 moose, 2 mountain sheep, 2 mountain goats, a season; 25 ducks, 15 geese, 15 brant, 25 in all of rails, coots, and gallinules, and 25 Wilson's snipe a day. Migratory game birds legally taken during open season may be possessed until April 14.

Export: Export of migratory birds prohibited during close season. Upon affidavit of lawful killing, commissioner may issue permit to export game. Export of raw hide of moose or caribou prohibited except under permit. Trophies, including head, hide, and hoofs, of big game lawfully killed by nonresident may be exported under his license and certificate of game guardian.

LAWS OF NEWFOUNDLAND

Open seasons:	*Dates inclusive*
Hare, rabbit	Oct. 1–Dec. 20.
Ptarmigan, willow grouse or partridge, geese, plover, curlew, snipe, or "other wild or migratory birds (except crows and hawks, unprotected)"	Oct. 1–Dec. 20.

Export: Export or canning of ptarmigan and other game birds prohibited.

Miscellaneous: Use of repeating or automatic shotguns prohibited.

LAWS OF MEXICO

Open seasons:	*Dates inclusive*
Deer (male), north of twentieth parallel	Oct. 16–Jan. 31.
South of twentieth parallel	July 16–Oct. 15.
On Cedros Island	No open season.
Antelope, mountain sheep	No open season.
Bear	Sept. 1–Oct. 31.
Rabbit	Sept. 1–Feb. 28.
Peccary	Aug. 1–Feb. 28.
Grouse	Sept. 1–Sept. 30
Quail, partridge	Jan. 1–Apr. 30.

Open seasons—Continued	*Dates inclusive.*
White-winged doves	Sept. 16–Nov. 30
Other doves and pigeons	Oct. 1–Dec. 31.
Wild turkey (see exception), cojolite	Sept. 1–Dec. 31.
Exception: Wild turkey in Coahuila, Nuevo Leon, and Tamaulipas	Feb. 15–Apr. 30.
Armadillo	Nov. 1–Jan. 31.
Tapir	Sept. 1–Nov. 30.
Ducks, geese, shore birds	Nov. 1–Feb. 28.

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[34] *Yukon:* Indians, explorers, surveyors, prospectors, miners, and travelers in need of food may take game during close season. Commissioner in council may alter seasons.

FIELD SERVICE, DIVISION OF GAME MANAGEMENT, BUREAU OF BIOLOGICAL SURVEY

[Violations of Federal game laws may be reported to the nearest official listed, or to the Chief, Bureau of Biological Survey, U. S. Department of Agriculture, Washington, D. C.]

REGIONAL GAME-MANAGEMENT DIRECTORS

Pacific region (no. 1)	Ira N. Gabrielson, 404 United States Courthouse, Portland, Oreg.
Mountain-Plains region (no. 2)	Leo L. Laythe, 221 Customhouse, Denver, Colo.
Southwestern region (no. 3)	Don A. Gilchrist, 404 Federal Building, Albuquerque, N. Mex.
West Central region (no. 4)	George Tonkin, Federal Building, Winona, Minn.
Southern region (no. 5)	Roy Moore, State College, Miss.
East Central region (no. 6)	Daniel H. Janzen, care G. C. Oderkirk, Purdue University, Lafayette, Ind.
South Atlantic region (no. 7)	James Silver, Biological Survey, Washington, D. C.
Northwestern region (no. 8)	Bertrand E. Smith, Massachusetts State Agricultural College, Amherst, Mass.

SUPERINTENDENTS OF FEDERAL WILDLIFE REFUGES

Ray C. Steele	Upper Mississippi River Wildlife and Fish Refuge, Federal Building, Winona, Minn.
George E. Mushbach	Bear River Migratory Bird Refuge, Box 603, Brigham City, Utah.

UNITED STATES GAME-MANAGEMENT AGENTS (REFUGE)

George M. Benson	Lake Malheur Bird Refuge, Princeton, Oreg.
Steven B. Crossley	Big Lake Bird Refuge, Manila, Ark.
Geno A. Amundson	Niobrara Game Preserve, Valentine, Nebr.
H. Harrison Hoyt	Wind Cave Game Preserve, Hot Springs, S. Dak.
Almer P. Nelson	Elk Refuge, Jackson, Wyo.
Wesley D. Parker	Sullys Hill Game Preserve, Fort Totten, N. Dak.
Robert S. Norton	National Bison Range, Moiese, Mont.
Hugh M. Worcester	Tule Lake and Clear Lake, Bird Refuges Calif.; and Upper Klamath Wildlife Refuge, Oreg.; Box 50, Merrill, Oreg.
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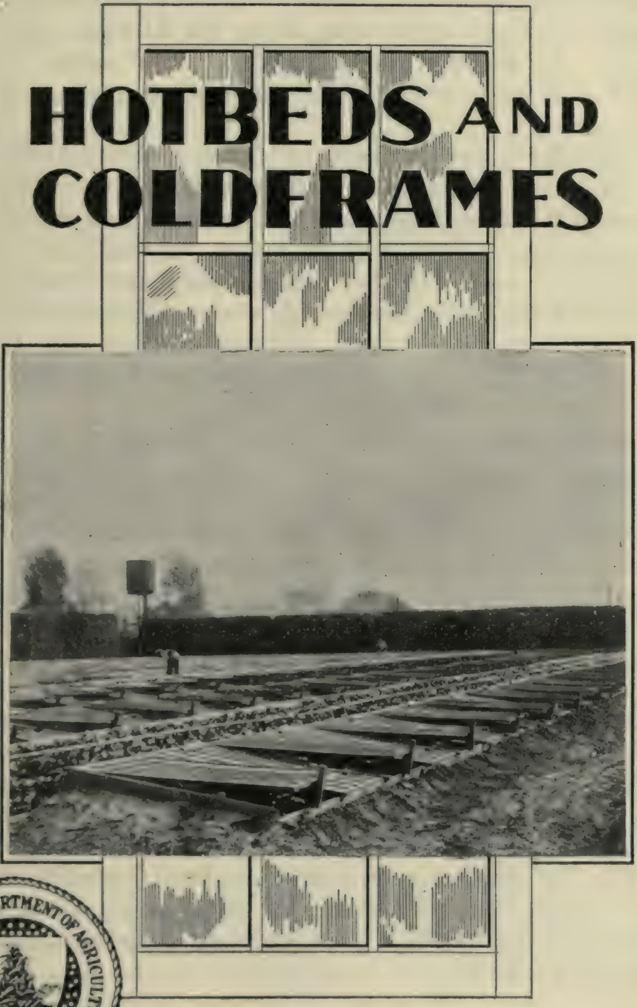
U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1743

HOTBEDS AND COLDFRAMES



HOTBEDS AND COLDFRAMES are being used by home and market gardeners for starting early plants, especially in sections of the country where the growing season is short and it is desirable to advance the development of certain crops. Coldframes are being extensively employed for the growing of a number of vegetable crops to a marketable stage, especially in sections along the Atlantic coast where the weather during the fall and spring is mild and only a moderate amount of protection is necessary.

With the present scarcity of horse-stable manure suitable for the heating of hotbeds, growers are turning to other forms of heating, including wood-burning flues, steam, and hot water. Recently, electricity has come into the field of plant-bed heating and has been found practicable under favorable conditions, especially where electric current can be secured at a low rate and where accurate temperature control is desirable.

Conservation of heat is an important factor in the construction and operation of hotbeds and coldframes, and numerous types of mats and coverings for protecting the beds have been devised. The growth of plants in hotbeds is greatly hastened as a result of raising the soil temperature, but care must be taken to control the temperature and to accustom the plants to outdoor conditions before they are set in the open ground.

Many gardeners have constructed small greenhouses and more or less permanent plant-growing structures in which to sow seeds and start early plants, but coldframes are desirable for use in gradually tempering the plants to outdoor conditions.

For the convenience of growers, brief instructions are included in this bulletin for the growing of early plants in the various types of plant-growing structures described.

Washington, D. C. Issued February 1935

HOTBEDS AND COLDFRAMES

By W. R. Beattie, *senior horticulturist, Division of Fruit and Vegetable Crops and Diseases, Bureau of Plant Industry*

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INTRODUCTION

EARLINESS is an important factor to both home and market gardeners in the production of such crops as tomatoes, peppers, eggplant, lettuce, and other vegetables that can be readily transplanted. Various forms of plant-growing structures, including greenhouses, sash houses, hotbeds, plant pits, and coldframes, are being used by gardeners for starting early plants, the type of structure or frame used depending largely on climatic and other local conditions. In the past, when an abundance of horse manure was available, the manure-heated hotbed was used almost exclusively, but with the present shortage of horse manure, growers have turned very largely to fuel-heated beds for starting early plants. The tendency is also toward using greenhouses more generally for starting early plants, but continuing the employment of coldframes for tempering the plants to outdoor conditions before setting them in the open.

In determining the type of house or bed to use for starting early plants, the grower must first consider the temperature and other climatic conditions under which he is working. His object is to produce good, stocky, well-built plants that will stand transplanting to the open without serious checking of their growth. Under certain climatic conditions this may require the use of a heated greenhouse. Under other conditions this end can be best attained by the employment of manure- or fuel-heated hotbeds, while in still other cases, where only slight protection is required, a cloth- or sash-covered coldframe may be sufficient. In this bulletin the various types of plant-growing beds are discussed, together with suggestions as to their management and the proper treatment of the various kinds of plants that are commonly grown under protection during the early spring or the late fall.

Hotbeds and coldframes are frequently used in regions with a mild climate, for growing to a marketable stage certain vegetables such as cucumbers, beets, radishes, carrots, parsley, lettuce, and occasionally muskmelons. In some cases sash-covered frames are employed for the early crop, and after it is well started and the danger of injurious temperatures is past, the frames are removed and the crop matured in the open. This is known as frame culture. It is used most extensively by growers along the Atlantic seaboard where the natural heat of the sun during the early spring and late fall is sufficient to maintain a growing temperature. Where this system is used for growing late-fall crops the plants are started in open beds; then as the weather becomes cool the frames are placed in position and the sash or cloth covering put on. The reverse plan is followed in the spring.

Where hotbeds or coldframes are constructed of brick or poured concrete, the walls are usually made 4 inches thick and are carried 20 to 24 inches above normal ground level at the back and 10 to 12 inches above it at the front. The usual width of these beds having such walls is 6 feet from center to center of the walls, or approximately 5 feet 8 inches inside measurement. By making the tops of the walls conform to the slope of the bed, the sash will have 2 inches of a firm supporting surface on top of each wall. Where crosspieces are provided, upon which to slide the sash, they are embedded in the concrete or brickwork and are flush with the top of the walls. If desirable, a wooden housing for the upper end of the sash may be provided and embedded into the wall or fastened with bolts let into the wall.

Concrete and cinder blocks are being used quite extensively for the construction of the walls of hotbeds, coldframes, and small plant houses, on account of the ease with which they can be laid. In some localities concrete blocks 4 inches thick can be obtained, and walls constructed of these occupy less space than those made of the 6- or 8-inch blocks. Where concrete blocks are used for the front and back walls of the beds, it is necessary to put up forms and pour the top of the ends in order to obtain the correct slope. The 8- by 8- by 16-inch concrete and cinder blocks are especially adapted for constructing the walls of double beds with a ridge through the center and covered by means of two lines of hotbed sash or cloth. The top layer of blocks should be crowned with a layer of cement mortar about an inch in thickness to prevent water from entering the cavities of the blocks. Cinder blocks are better insulators against the passage of heat than concrete and, in addition, have the advantage that nails can be driven into them where wood is being fastened to the block walls.

Double plant beds 12 to 15 feet in width with concrete- or cinder-block walls are coming into more general use for plant growing, on account of low cost of construction. Where flue or hot-water heating is employed the side walls need be only about 16 inches, or two layers of blocks in height, above the ground level. Where sash are used as a covering, a plank is supported on posts through the center of the bed, and the double row of sash rest on this plank at the center and on the walls of the bed at the sides. The slope given the sash is usually from 12 to 18 inches for the full length of the 6-foot sash. If muslin or light canvas is used as a covering, the slope is increased to about 2 feet and side rafters or strips are provided on which the canvas rests.

LOCATION OF HOTBEDS AND COLDFRAMES

Hotbeds and coldframes should always be located on well-drained land that is free from depressions or danger of flooding during heavy rains. A location near the house where the beds can be given frequent attention is desirable. The beds should be protected on the north by a group of buildings, a grove of trees, a tight board fence, or an evergreen hedge. In many cases windbreaks, consisting of pine boughs or bundles of corn fodder set against supports, are employed for protecting the beds from cold winds. The growers around Norfolk and Portsmouth, Va., divide their frame yards into 1-acre sections by means of arborvitae and California privet hedges that attain a height of 12 to 20 feet, and very effectively break the force of the wind. (See cover illustration.) A location with a southern exposure and adequate wind protection on the north and west is ideal. In all cases, protection from cold winds, the securing of direct sunlight, and convenience in the matter of tending should be the main determining factors in the selection of a location for any type of plant bed.

Plant beds and small greenhouses built well below the level of the ground require less heat than those that are entirely above ground and more exposed. This principle applies especially to the construction of sash-covered houses that are heated by flues, stoves, or electricity. Special care must be taken, however, in the selection of a location for beds and houses that are partially below ground, to provide good drainage in order to avoid flooding the beds during rainy seasons.

Plants grown in hotbeds and coldframes require rather frequent watering and, if possible, the beds should be located where water can be piped to them. In some cases a well is dug or drilled near the beds and a pump installed to supply the water. Where the beds are of a very temporary nature, water is sometimes hauled in barrels or tank wagons and applied to the plants by means of sprinkling cans. In any case an adequate supply of water for watering the plants must be provided. In the east-Texas tomato fields several barrels of water are hauled and placed alongside each bed at the beginning of the plant-growing season. In other instances water is hauled in tank wagons or in the tanks of orchard sprayers and is applied to the plant beds through a hose having a rose or sprinkler on its end. The most convenient method of watering the plant beds, however, is by means of water under pressure piped direct to the beds.

MANURE HOTBEDS

Where manure is plentiful, temporary hotbeds may be provided by simply placing a flat pile of manure 8 or 9 feet in width, 12 to 24 inches in depth, and of any desired length, on top of the ground in a well-drained location, and setting frames of boards on top of it to contain the soil and support the covering of sash or cloth. Additional manure is then banked around the outside of the frames to retain heat.

The frames usually consist of 1-inch boards, preferably cypress, redwood, or white pine, 12 inches wide, 1 board being used for the front or south side and 2 boards, 1 above the other, for the back or north side. These boards are nailed to stakes driven through the bed of manure and into the ground, the lines of boards being 5 feet 8 inches apart so that the space between them can be covered with standard 3- by 6-foot hotbed sash that rest on the edges on the boards that form the sides of the bed. Sectional or portable frames with sloping ends to carry 4 or 5 standard sash are often constructed, and where a long bed is required the sections are placed end to end, making a continuous bed.

The preparation and handling of the manure used in making a temporary hotbed of this character are practically the same as those described herein for more permanent beds.

About 5 inches of good soil (or sand if sweetpotato plants are to be grown) should be spread on top of the manure in the frames before the sash is put on. This method of constructing manure-heated beds avoids the necessity of digging a pit but requires about twice the amount of manure. However, this material is usually in good condition for top-dressing land or for use in making plant-bed soil at the close of the plant-growing season.

A more permanent method of constructing a manure-heated hotbed, one which will require the use of a relatively small amount of manure, is to dig a pit 6½ or 7 feet in width, from 14 to 30 inches in depth according to the severity of the climate, and of any desired length, the length usually being determined by the number of standard 3- by 6-foot sash that are to be used as a covering. The pit should be laid off with a line attached to stakes, as shown in figure 1, and then dug to the desired depth. It should then be lined with planks, as shown in figure 2, or with more permanent walls of brick, cement blocks, poured concrete, or some other material. The walls may extend aboveground to the desired height, and the sash rest directly upon them; or a framework of boards, 20 to 24 inches high at the back or north side and 10 to 12 inches high at the front or south side, may rest upon walls that come only to the ground level. If permanence is desired, the beds should be constructed entirely of the more durable materials with only such wood materials as are necessary to properly fit the sash tightly to the walls. In some cases crosspieces are provided upon which the sash rest, and this is a decided advantage for drawing down the sash for ventilation. An additional advantage is gained by having separation or guide stops between each sash so that there will be no danger of the sash slipping off the supporting members. The ends of the bed are cut on a slope to conform to the pitch or slope of the sash.

Manure for use in hotbeds should consist of a good grade of straw-bedded horse or mule manure; this should be hauled direct from the stable and should not be allowed to remain in piles where it will ferment and lose its heating qualities. The method of preparing and placing the manure in the pit of the hotbed is also of considerable importance. As it is hauled from the stable it should be placed

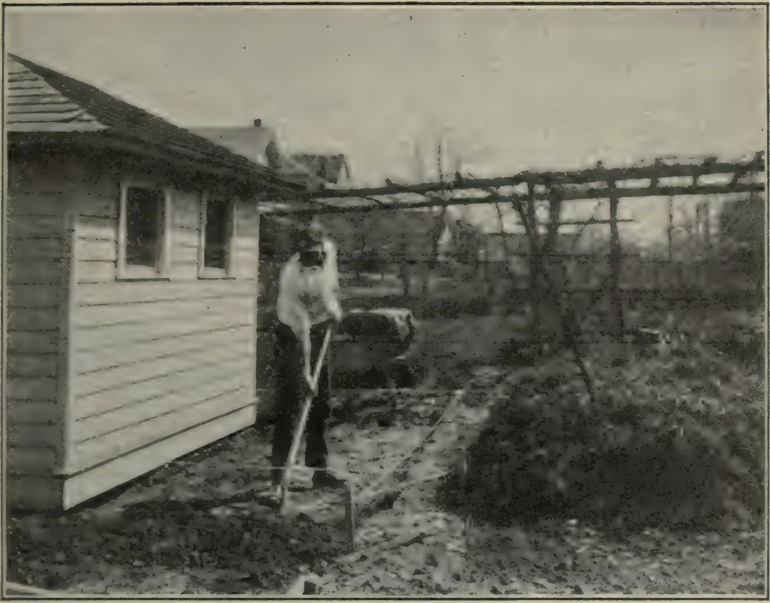

FIGURE 1.—Laying off and starting to dig a pit-type manure-heated hotbed.

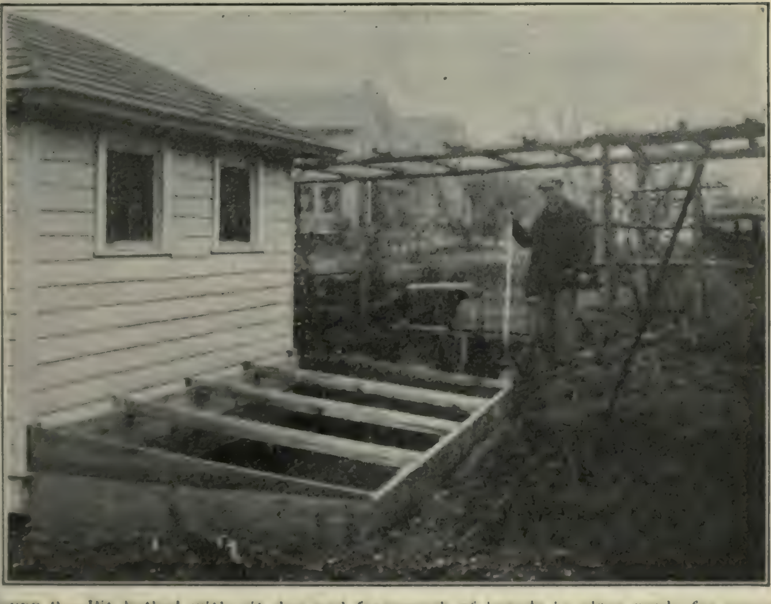

FIGURE 2.—Pit hotbed with pit dug and framework of boards in place ready for manure to be forked into the bed.

in broad, flat piles alongside the hotbed, to remain 2 or 3 days, until it begins to heat; it should then be turned or forked over so as to secure uniform composition and heating. In case the manure is a trifle dry and shows a tendency to firefang or burn, a little water should be added as it is being turned. After 4 or 5 days, or as soon as the manure has begun to heat uniformly, it should be forked into the hotbed, care being taken to shake out all lumps and to spread the manure evenly in the bed. Figure 3 illustrates the proper method of trampling the manure as each layer is added. In case the manure is dry at the time it is being forked into the hotbed, a little water should again be added, but too much water may delay the heating.

The depth of the manure in the hotbed will depend on the outside temperatures. In localities where the temperature does not go below 12° F. during the plant-growing period, a layer of manure 12 to 15 inches thick will be sufficient, provided the bed is well banked on the outside and some form of covering is used over the sash during periods of low temperature. The depth of the layer should be increased 1 inch for each degree of lowered temperature, about 24 to 28 inches of manure being used under conditions of 0° temperature. Following the placing of the manure in the bed, about 5 or 6 inches of screened garden loam should be spread evenly over the manure, and the sash put on to retain the heat. If sweetpotato plants are to be grown in the bed, clean sand should be used instead of the garden loam.

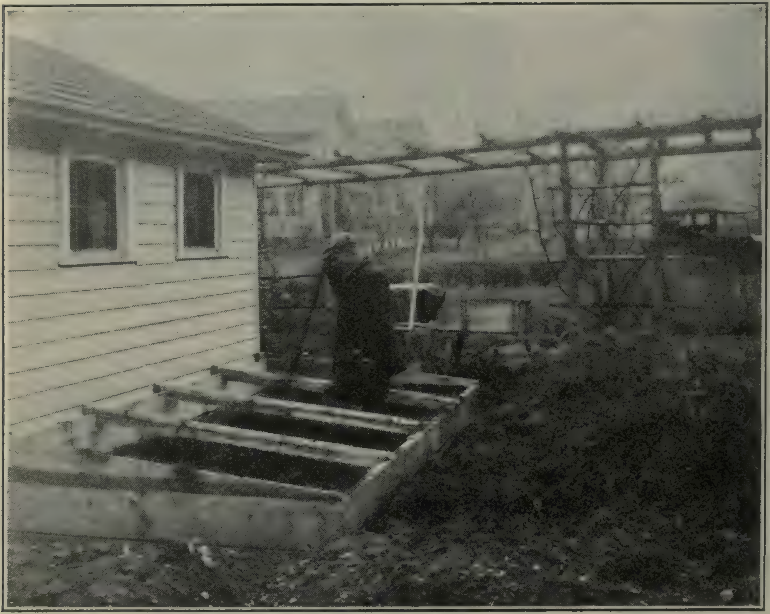

FIGURE 3.—Trampling manure in pit of hotbed.

Figure 4 shows a small hotbed completed and the sash in place.

Cornstalks taken from the feed lot after the cattle have stripped the blades and husks from them have been found to be a good substitute for manure as a source of heat for hotbeds. The cornstalks are run through a silage cutter, then moistened and packed in the pit of the hotbed in exactly the same manner as manure. In the hotbed they go through a heating or fermentation process resembling that which takes place in a silo, and this results in the formation of enough heat to keep the plant bed warm over a period of 1 to 2 months. The labor involved in gathering the cornstalks from the feed lot and cutting them is largely offset by their disposal and conversion into readily available compost by the end of the plant-growing season. Where large quantities of cornstalks are to be used for hotbed heating the cutter should be placed alongside the beds and the chopped material blown directly into the beds. Where the quantity of manure for hotbed heating is limited, its volume and effectiveness can be increased by the addition of chopped or shredded corn fodder.

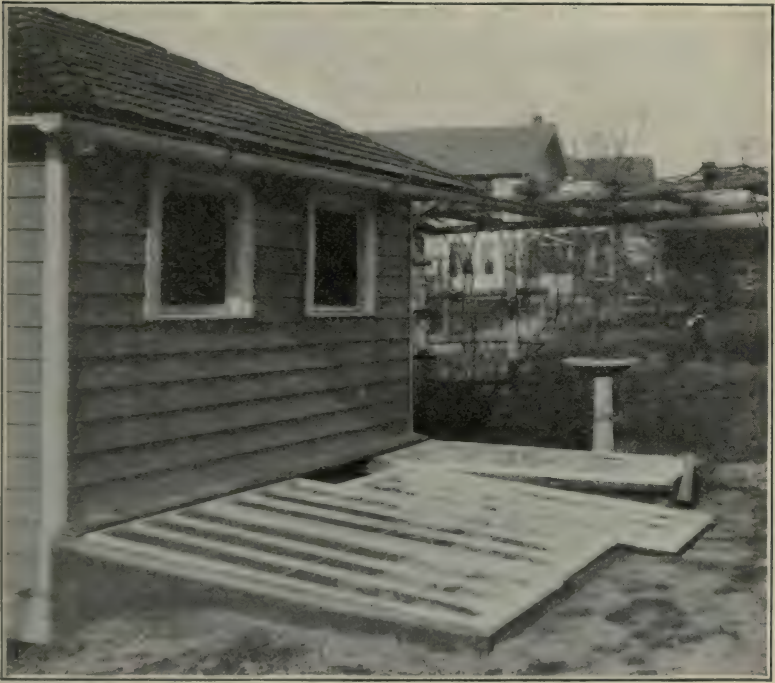

FIGURE 4.—The completed pit hotbed with sash in place.

When a manure-heated bed is first made it is likely to heat very rapidly; the temperature may run into the 90's, or even above 100° F. This is too much heat, and the sowing of the seed should be delayed until the temperature falls to about 85° or lower. It is not safe to judge the temperature of the soil by feeling it. A thermometer should be used, its bulb buried in the soil to about the depth to which the seeds are planted. If at least 5 inches of sifted soil is placed over the manure in the bed, this soil will have a tendency to take up the heat given off by the manure, but it may be necessary to control the temperature by ventilation. Later, as the temperature of the manure in the bed declines, it may be necessary to bank more manure around the outside of the bed to maintain a proper temperature. If extra manure is not available, the outside of the bed should be securely banked with earth, marsh hay, straw, pine needles, or some other good insulating material.

FUEL-HEATED BEDS

Fuel-heated beds of various types are now largely replacing manure-heated beds, especially in sections where fuel is reasonably cheap, and where the manure supply is limited. The most common type of fuel-heated bed consists of a wood-burning furnace with one or more brick or tile smoke flues running underneath a floor upon which the soil is placed. Formerly, the fuel used in heating these beds consisted mainly of stumps and rough wood obtained when the land was cleared, but recently a type of furnace adapted to burning coke and hard coal is sometimes used. The present trend, however, is toward the pipe-heated bed in which hot water is employed as the medium of heat transmission. Where steam can be supplied at a constant but low pressure from a large or centralized boiler, as, for example, from a factory boiler, it may be used for heating hotbeds during the plant-growing season, but steam heat is a little too intense and not so easy to control as hot-water heat. Where steam is being used on a fairly large scale for heating plant beds the adoption of the vapor system will largely overcome the objection to steam. Steam heat does not require such large piping as hot-water heat, and sudden changes in temperature can be met to better advantage than with hot-water heat.

FLUE-HEATED BEDS

The truck growers of New Jersey and of the Eastern Shore, including Delaware and parts of Maryland and Virginia, use flue-heated beds very largely for starting early plants, especially tomatoes, peppers, and sweetpotatoes. These beds may be located on level ground, but oftener a location having a slight rise is selected. A pit about 18 inches deep, 8 to 12 feet wide, and 50 to 60 feet long is excavated, and the sides and ends are provided with plank, brick, or concrete walls extending 8 inches to a foot above the natural level of the soil. Frequently the pit is simply lined with boards nailed to stakes driven into the ground. In that case the boards extend about 12 inches aboveground to form the sides of the bed. A brick or stone furnace is built in a pit at the lower end of the bed, but outside the bed proper. A flue consisting of 6-inch or 8-inch round tile is connected with the furnace. Usually this flue is carried the full length of the bed and fitted with an elbow, and 3 or 4 joints of pipe are placed upright to form a chimney. In some cases two flues connected with the furnace are carried about half the length of the bed, and the smoke is discharged into the space under the floor of the bed, from which it eventually finds its way to a chimney at the end of the bed. The floor consists of planks laid on cross timbers which rest on the walls or on stone pillars at the sides.

The covering for these beds sometimes consists of marsh hay, but often it consists of heavy muslin or light canvas sewed together in a large sheet of sufficient size to cover the whole bed. A ridgepole is placed the full length through the center of the bed, and is supported on uprights about 2½ feet above the floor of the bed. Rafters or 1- by 3-inch or 1- by 4-inch strips are then fastened to the ridge and the sides of the bed every 3 or 4 feet to support the cover. At the sides of the bed the cover is fastened to long wooden strips on which it can be rolled up for ventilation or for watering. A bed of this type with marsh hay as a covering for the plants is shown in figure 5.

In some localities new railroad ties that have been rejected by the inspectors on account of some defect are used as supporting timbers for the floors of flue-heated beds. In that case the beds are made 8½ feet wide to conform to the length of the crossties. After the pit is dug, stone or brick pillars are built at intervals of 4 feet along the sides, and the crossties are laid with their ends resting on these stone or brick pillars. A floor of 2-inch planks is then laid upon the crossties; planks are placed on edge and are fastened to stakes to form the sides. In some cases brick or stone walls are used for the sides, and old boiler tubes or junk-yard pipe is let into the walls to form the cross supports. Old roofing tin, parts of old automobile bodies, or any discarded sheet metal may be used as flooring for these beds. The metal flooring and supports are strictly fireproof. However, there is little danger of fire with the wooden floors because of the low degree of heat maintained.

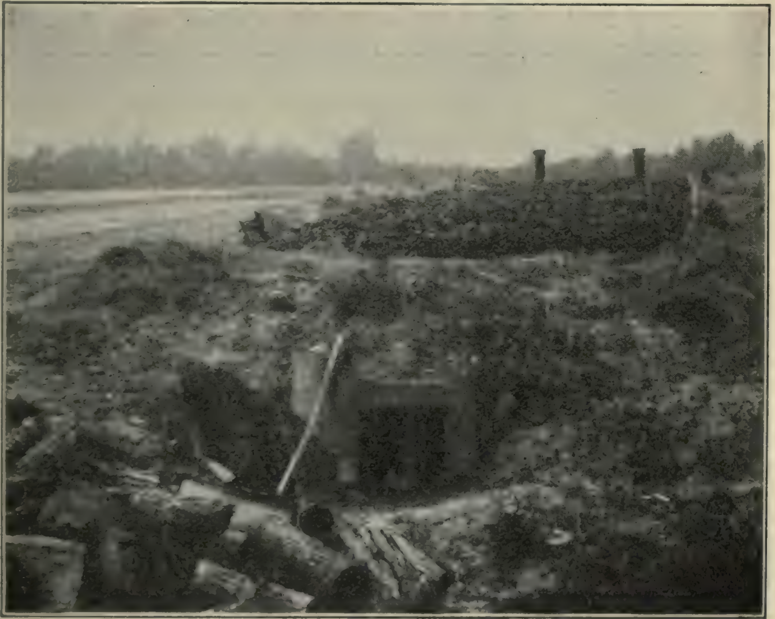

FIGURE 5.—A flue-heated plant bed having two flues or smoke ducts running the full length under the floor of the bed. Marsh hay is used as a covering for the bed.

Instead of building a furnace of brick or stone, many growers cut one end out of an old 50-gallon steel oil barrel, and cut a hole in the opposite end large enough to admit the end of a 6-inch tile. The barrel is then buried on its side in a pit at one end of the bed, and a 6-inch tile is run from the opening of the barrel the full length of the bed under the floor, terminating in a chimney at the farther end of the bed. This chimney often consists of a wooden box which is carried 3 to 5 feet above the surface of the ground. Chunks of wood about 18 inches in length and 6 to 10 inches in diameter are used as fuel, and green sawdust is frequently placed on top of the wood in the furnace in order to give a slow-burning or smoldering fire. According to statements of growers, 1 cord of wood is sufficient to fire a bed of this character during a plant-growing season, and the fires require attention but twice in 24 hours. A piece of sheet iron held in place by an iron bar is used as a front door for the furnace. When an extremely slow fire is desired, a piece of tile or a flat stone is laid partly over the chimney.

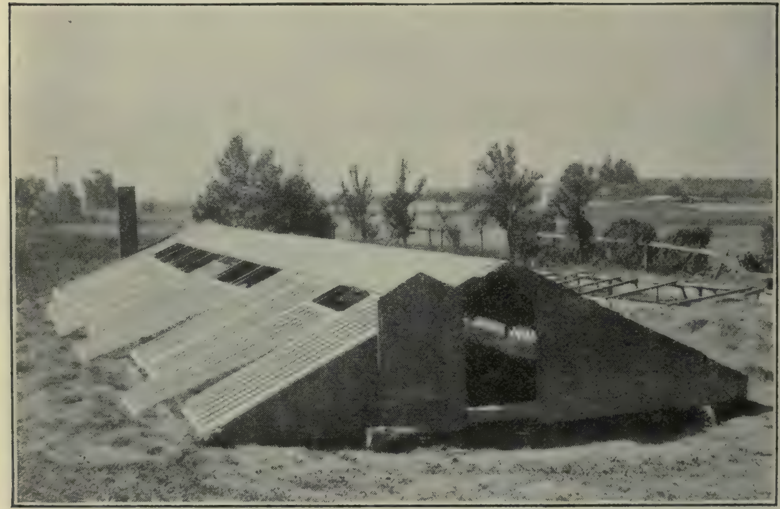

FIGURE 6.—Type of flue- or stove-heated bed used by growers in southern New Jersey for starting early eggplant, tomato, and pepper plants.

About 8 inches of good soil is placed on the floor of the bed in which the plants are to be grown, or, in the case of sweetpotatoes, sand is used. A bed of this type is shown in figure 5. Where sweetpotatoes are started in such beds, marsh hay is used almost exclusively as a covering, about 3 or 4 inches of the hay being spread loosely over the surface of the bed and the sweetpotato plants simply allowed to grow up through it. After the plants are well started, the hay is carefully removed with forks and rakes.

New Jersey growers frequently use a plant-growing bed of the type illustrated in figure 6. These beds or plant houses are constructed with a furnace pit and a smoke flue running from the furnace at the one end to a chimney at the other end. As a rule, the dimensions of these houses are 12 or 14 feet by 50 to 60 feet, with solid side beds and a walk through the center. Doors are provided at each end for convenience, and the covering consists of a framework on which hotbed sash rest. In the center of the bed and over the walk, the roof is constructed of boards that are covered with roofing paper or with tin. The sash are so arranged that they slip under the roofing at the top and can be either slid down or raised for ventilation. This type of bed or plant house has the advantage that the work of sowing seeds and transplanting can be done under cover during bad weather. During the summer and fall when the bed is not in use, the sash are removed and stored under shelter. In some cases the furnace and flues are omitted, but a stove is installed at one end, with a stovepipe running the full length of the house to supply the necessary heat. Where wood is plentiful, wood-burning stoves of the airtight type are used; where it is not to be had at a low cost, hard-coal stoves are employed on account of the uniformity of heating and the small amount of care required. In many cases these beds are being replaced by simple but effective greenhouses.

PIPE-HEATED BEDS

Another type of fuel-heated bed that is gaining popularity is constructed on level or nearly level ground with concrete side walls 12 to 18 inches high and lines of steam or hot water pipes buried in the soil. Heat is obtained from a boiler located either in a pit at one end of the bed or in the basement of a service building nearby. In New Jersey, especially on farms where poultry is kept in connection with vegetable growing, the heater is placed under the workroom or tool room and supplies heat for both the hotbeds and the brooding houses. The heating pipes are usually laid lengthwise of the bed with the lines of piping 12 to 18 inches apart and at about the original soil level. The pipes should have a uniform fall of at least 6 inches in the length of a 60-foot bed, and should rest on solid earth or on bricks placed every 3 or 4 feet to prevent their settling and forming air pockets. Soil is filled in over the pipes to within about 6 inches of the top of the concrete walls, the pipes thus being 12 to 14 inches below the surface of the soil in the bed. A feed pipe is sometimes carried from the boiler to the far end of the bed, either along the ridge or on the side of the bed. It is there divided to supply the return pipes which are buried in the ground. More frequently, however, half of the pipes are used as flows and the other half as returns, the flows being elevated about 6 inches above the returns at the end of the bed next to the heater. Where this plan is followed, it is essential that the beds be located on a comparatively level piece of ground to obtain a uniform grade of the pipes both leaving and returning to the heater. Beds of this character are especially adapted for starting sweetpotato plants, and for peppers and eggplants which require an abundance of bottom heat. Figure 7 shows a cross section of a bed of this type.

Pipe-heated beds are also constructed with walls like ordinary 6-foot wood-frame or concrete hotbeds, but with the pipes arranged around the interior of the bed above the soil, the flow pipe being at the back or high side, and the return pipe at the low side and supported by pipe hangers or wires to the crossbars on which the sash rest. This type of bed gives good results where bottom heat is not required and where it is desired to grow stock plants somewhat slowly with merely enough heat to safeguard against low temperatures that would seriously check growth. Early plants of cabbage, cauliflower, lettuce, celery, and tomatoes can be grown to advantage in beds of this character. Figure 8 shows a cross section of this form of bed.

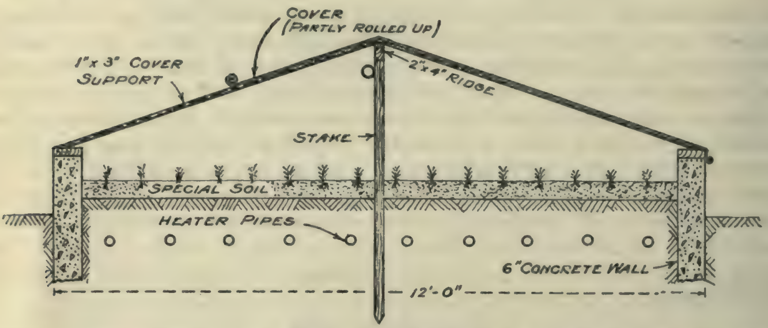

FIGURE 7.—Cross section of bed with heater pipes buried in the soil, the heat being supplied from a boiler.

ELECTRIC HEATING OF BEDS AND PLANT HOUSES

For many years electricity has been used as a source of heat for plant-growing structures in Norway, Sweden, and other sections of northern Europe where water power has been extensively developed and electric energy is comparatively cheap. Experiments in this country, especially those conducted by the State college and experiment station workers in certain States, have shown that under favorable conditions, electric current may be effectively and economically employed for heating outdoor plant beds and indoor propagating

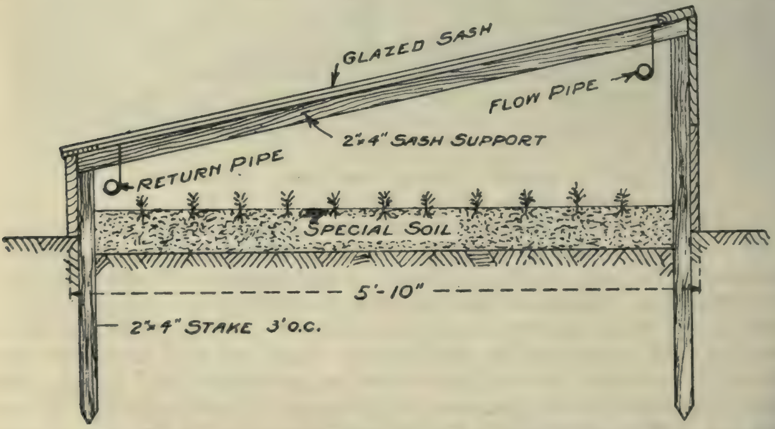

FIGURE 8.—Cross section of plant bed with two lines of heater pipes suspended from sash-support bars. For steam or hot-water heat.

and seed-sprouting beds.[1] The first cost of installation, and the securing of suitable heating elements, together with the relative cost of electric energy as compared with manure and other sources of heat for plant beds, have been the limiting factors in the adoption of this form of heating.

This system has been found well adapted for heating propagating beds and small beds in which seeds are started. Figure 9 shows a bed of this character with the heater cable laid in the form of a coil in the bottom of the bed and partly covered with sand. The thermostat is also embedded in the sand and connected with the switch box and the feed wires at the end of the bed. The desired temperature may be easily maintained, but the main point is to have the bed well insulated to conserve the heat. One of the advantages of this form of heating for a seed or propagating bed is the uniformity at which the temperature may be maintained. The temperature can be regulated by simply turning the thermostat knob one way or the other, and when once regulated, the control is automatic.

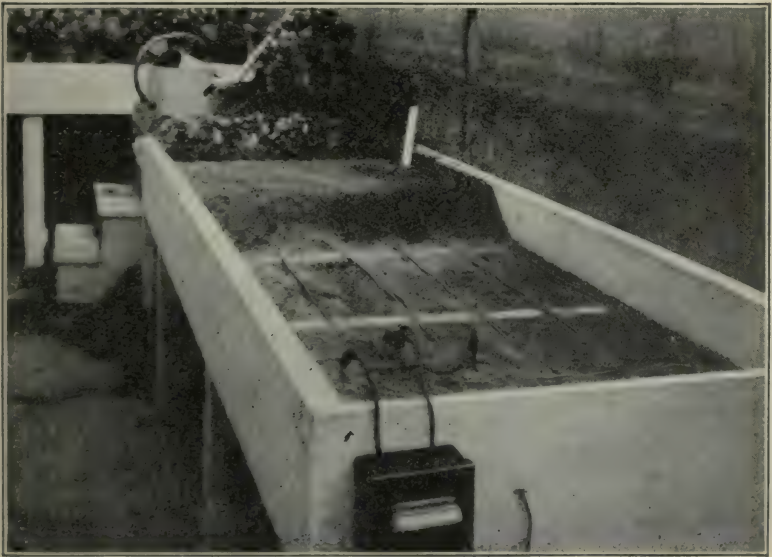

FIGURE 9.—Electrically heated propagating bed showing heater cable in place before the bed was completely filled with sand or soil.

Various types of heating units have been developed, the earlier types consisting of an open framework of wood or metal across which heating elements were stretched on insulators. These units were usually of the proper size and capacity for heating a 1-sash bed, 3 by 6 feet, and the frames carrying the heating elements were mounted in an enclosure underneath the floor of the bed. Later types of heating elements are insulated and enclosed in lead or copper cables that may be buried in the soil. These cables are made in various lengths, 60 feet being the length best adapted for use with the ordinary service current of 110 volts. One 60-foot cable is required for a 2-sash or 6- by 6-foot bed, and two 60-foot cables for a 4-sash or 12-foot bed where relatively high temperatures are desired. For a very moderate heat one 60-foot cable will be sufficient for a 4-sash bed 6 by 12 feet. Each 60-foot cable will carry an electrical load of approximately 403 watts, or about the amount of current required to operate ten 40-watt electric-light bulbs. The arrangement of the cables in the bed is shown in figure 10.

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[1] Wash. Agr. Expt. Sta. Bull. 219, Manure and Electric Hotbeds; Mo. Agr. Expt. Sta. Bull. 304, Electric Hotbeds; Idaho Agr. Expt. Sta. Circ. 68, Electric Soil and Hotbed Heating; Oreg. Agr. Expt. Sta. Bull. 307, Electric Hotbeds and Propagating Beds; Minn. Agr. Expt. Sta. Bull. 289, Methods of Supplying Electric Heat to Hotbeds; and National Rural Electric Project Repts. 5 and 6, Md. Agr. Expt. Sta., College Park, Md.

Heat conservation is the keynote in handling electrically heated plant beds. The sides and ends of the beds should be tight, and, in addition, should be banked to the top with earth or some material to conserve heat. The sash should fit snugly, and, if needed to make the joints tight, strips of felt or rubber should be tacked to the edges of the bed on which the sash rest. The glass should be well bedded in putty, and should lap one-fourth inch at the joints. In addition to the glass, the beds should be covered with straw or felt hotbed mats during cold nights. In case of extremely cold weather the sash may be doubled by placing one sash on top of another, and banking the edges of the sash with straw, pine needles, or with leaves held in place by means of boards.

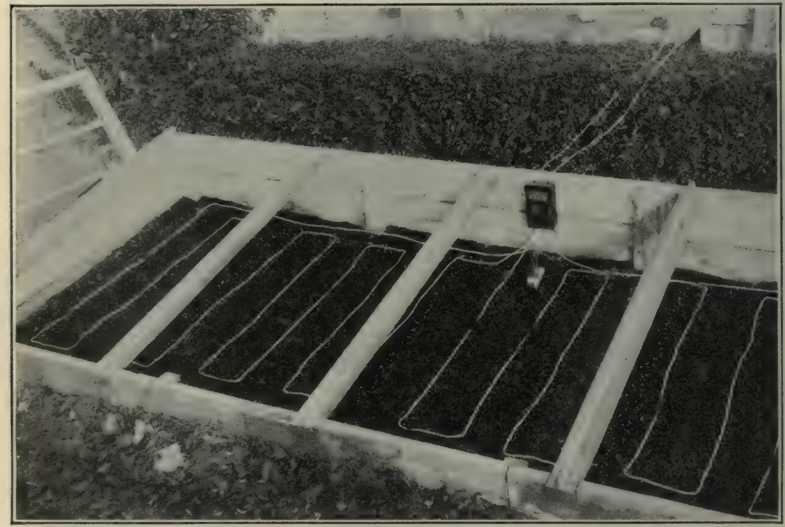

FIGURE 10.—Arrangement of heater in an ordinary 6- by 12-foot hotbed.

Electrically heated plant beds have a decided operating advantage over the ordinary manure- and fuel-heated beds in that the amount of heat can be automatically controlled by the use of thermostats or regulators, thus avoiding extremes. In the case of manure-heated beds the temperature usually runs too high at first, then declines rapidly, and finally becomes completely exhausted. Another advantage over manure heating is that the electric heating is free from odors or gases, and no steam or excessive moisture is formed. Electrically heated beds require very little attention to ventilation, except on very bright days when the heat of the sun is sufficient to raise the temperature of the bed above the maximum for the best plant growth. Where electric current can be obtained at a power rate the cost of heating plant beds compares favorably with manure heating at present prices of manure. When once the electric system is installed very little labor is required to renew the surface soil and get the beds in shape for planting. The copper and lead cables are highly resistant to corrosion, and, unless injured by tools, should last for years. Because of the uniform control of temperature, it is reasonable to expect that better plants can be grown with electric heat than with manure heat. Plants grown in electrically heated beds usually require a little more attention to watering than those grown in manure-heated beds.

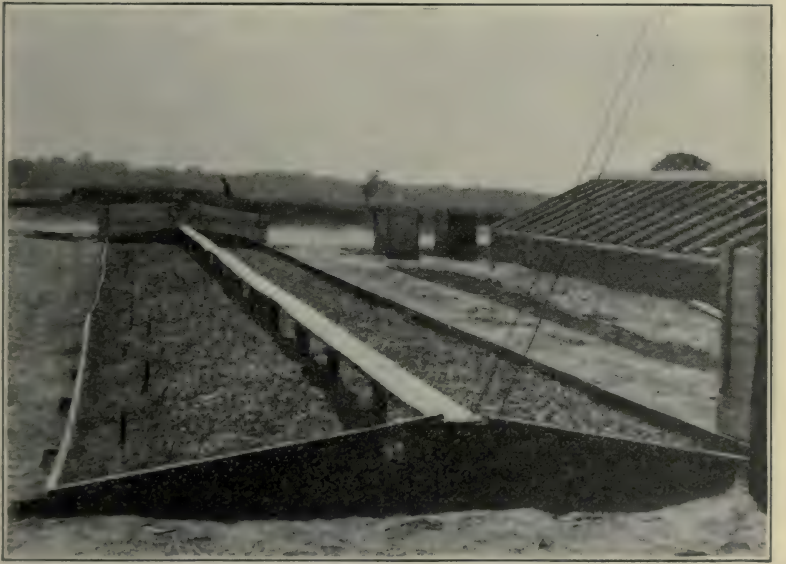

FIGURE 11.—Electrically heated plant bed with heater cables buried in soil and running the full length of the bed.

One firm in New Jersey has adopted electricity as the main source of heat for plant beds and small greenhouses in which early plants are grown. Figure 11 shows one of these beds in which the electric heating elements run the full length of the bed and are buried in the soil. Sash are used as a covering for this bed, and the soil temperature is controlled by an automatic thermostat. This firm is operating a number of sash-covered plant houses of the type shown in figure 12 which are electrically heated. Both the underground and overhead systems of heating are being employed in these houses to determine which gives the better results. Recently in a test of indirect electric heating, fans were used to drive the air over the heating elements and distribute it to the various parts of the house. This type of installation simplifies construction problems and gives a better circulation of heat than the old method of stringing the heating elements through the open spaces in the house. The action of the fans tends to provide better ventilation.

CONSTRUCTION OF COLDFRAMES

The construction of coldframes is practically the same as that of hotbeds, except that no provision is made for heating them artificially. Coldframes consisting of a framework of boards from 18 to 24 inches in height at the back or north side, and 8 to 12 inches at the front or south side, are generally built directly on top of the ground (figs. 13 and 14). Sometimes these beds are made in units of five sash each, with sloping ends and crosspieces to support the sash, but oftener they consist of two lines of boards fastened to stakes driven into the ground and without crosspieces, the sash resting on top of the edges of the boards forming the front and back of the bed. Frames of this character are used for the growing and hardening of early plants, the boards and sash being removed and stored as soon as the plant-growing season is over. This type of coldframe is also used extensively along the Atlantic coast for the growing to maturity of such crops as lettuce, beets, carrots, parsley, and cucumbers.[2] Figure 15 shows a 1-acre frame yard near Portsmouth, Va. Parsley was being grown in these frames when the picture was taken.

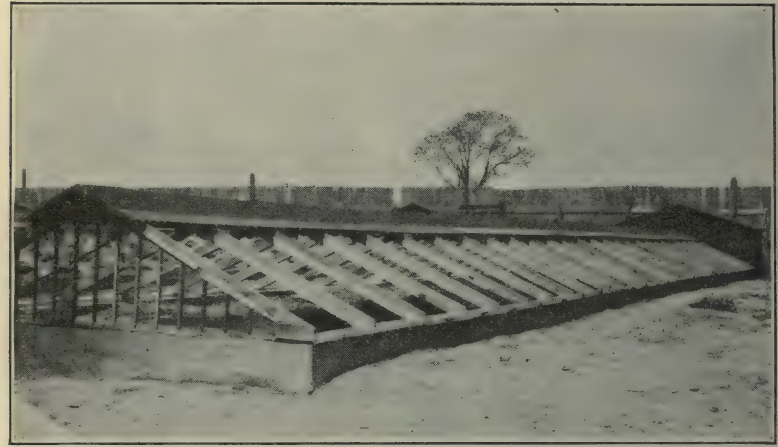

FIGURE 12.—An electrically heated plant bed in which both air and soil heating are employed.

COVERINGS FOR HOTBEDS AND COLDFRAMES

Coverings for both hotbeds and coldframes consist of standard hotbed sash, various kinds of glass substitutes, and cloth coverings such as muslin or light canvas. In some instances, a covering of straw or marsh hay is placed directly on the soil in the beds and is removed after the plants appear above ground, or the plants may be allowed to grow up through it, as is sometimes done in starting

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[2] Farmers' Bulletin 1563, Cucumber Growing, gives information on the use of coldframes for growing early cucumbers.

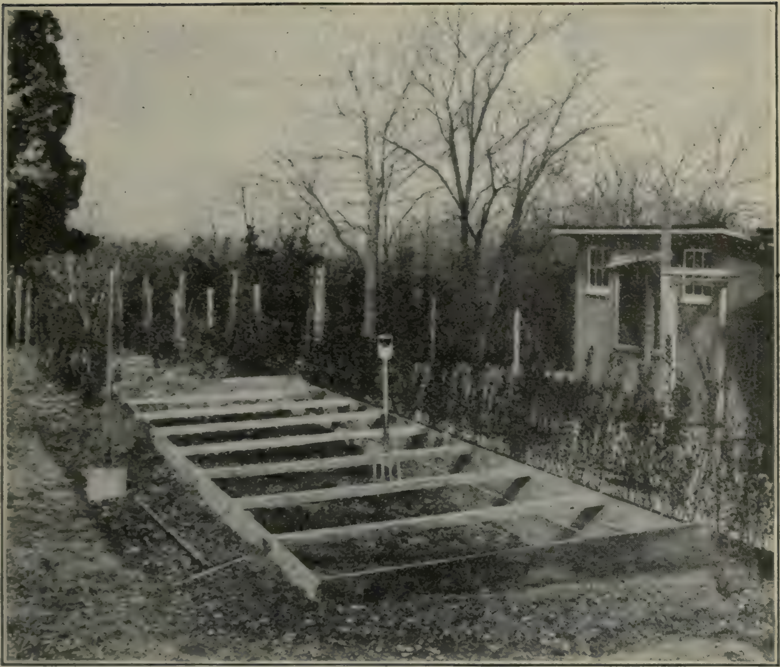

FIGURE 13.—Coldframe, constructed of boards nailed to stakes driven into the ground, ready for sash or cloth cover.

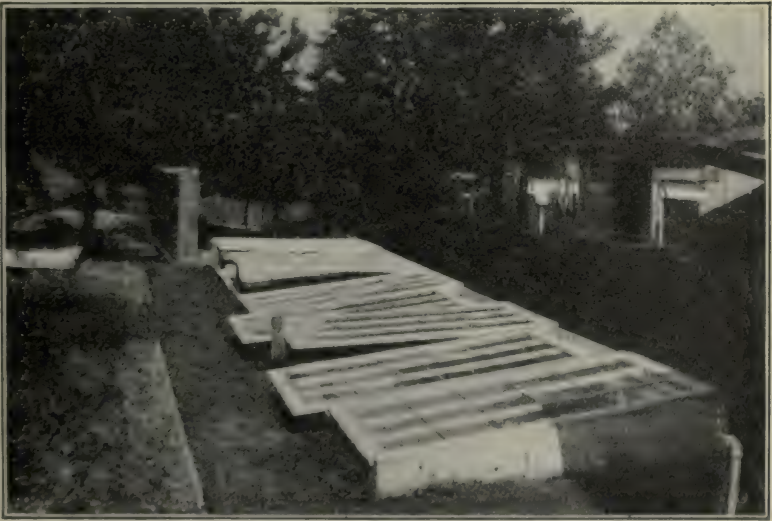

FIGURE 14.—Coldframe with sash covering in place.

sweetpotato plants. The most satisfactory covering for hotbeds and coldframes in the northern sections is glazed hotbed sash, supplemented by hotbed mats, board shutters, slat screens, and hay or pine straw. To the southward, where the covering can be left off the greater part of the time, a cloth covering, especially heavy unbleached muslin, has been found to give good results.

GLAZED-SASH COVERINGS

Standard hotbed sash are 3 feet wide, 6 feet long, and 1⅜ or 1¾ inches thick, and carry three rows of 10-inch glass. A reinforcing rod of ⅜-inch iron, or a strip of wood or metal, is placed across the center of each sash to strengthen it. These sash, made of clear gulf cypress, white pine, or California redwood, are kept in stock by dealers in greenhouse supplies and can be furnished unglazed and unpainted, unglazed and painted with 2 coats, or fully glazed with double-strength glass and painted with 2 or 3 coats of white-lead paint, according to the desire of the purchaser. Sash 4 feet in width and 7 to 9 feet in length can be secured on special order. The prices of hotbed sash vary according to the lumber market and the cost of labor and materials going into their construction.

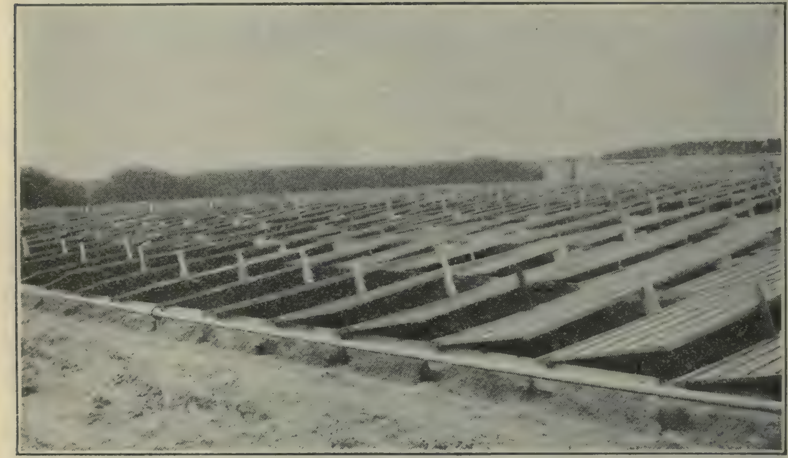

FIGURE 15.—One-acre frame yard near Portsmouth, Va., where a crop of parsley is being grown. Note the method of ventilating.

Experience has shown that if the sash are kept well painted and are stored under cover when they are not in use, they will last from 10 to 20 years or even longer. The sash should be given a first or priming coat consisting of white lead and pure raw linseed oil, to which should be added enough turpentine to cause the paint to penetrate the wood. The second coat, which should be applied before glazing, should contain a little Japan drier to cause the paint to dry readily. As a rule it will pay to give the sash a third or finish coat of paint after glazing. Figure 16 shows the upper side of a standard 3- by 6-foot hotbed sash fully glazed and painted and ready to place on the hotbed.

Hotbed sash should be glazed with fresh or plastic putty that will spread evenly on the sash bars, or with one of the prepared glazing compounds that are applied with a putty gun. The glass should be firmly embedded in the putty, the lights overlapping one-eighth to one-fourth of an inch, beginning at the bottom of the sash. Each light of glass should be fastened with 4 zinc glazing sprigs, 2 of these being driven on top of the glass about an inch from its lower edge and 2 directly below the edge of the glass to hold it from slipping toward the lower end of the sash. Cut a piece of glass to fill the remaining space at the top of the course, being sure that it is forced well up into the groove, previously filled with soft putty, at the top of the sash. Trim off all surplus putty above and below the glass and do not putty above the glass as in glazing an ordinary window.

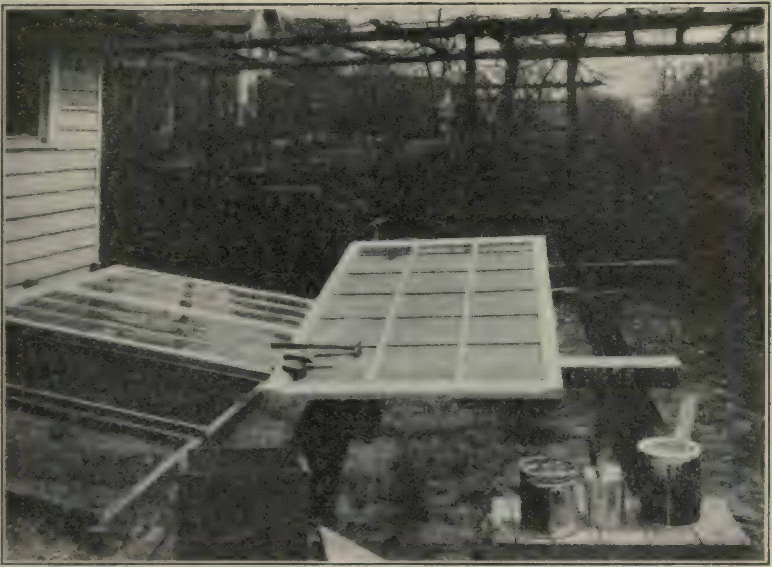

FIGURE 16.—Top view of a standard 3- by 6-foot hotbed sash, fully glazed, painted, and ready to place on the hotbed.

Hotbed sash, in which the sash bars are made with grooves into which the glass can be slipped without the use of putty, are commonly used in sections having a mild climate. As a rule 6- by 8-inch single-strength glass is used, the glass being pushed in from the lower end of the sash and the lights butted together. This type of glazing does not give as warm a covering for the beds as the regular puttied and lapped glass and is subject to greater dripping of rainwater upon the plant beds. The glazing of this type of sash is a very simple matter, and in case of a light of glass becoming broken a new light can simply be slipped in at the bottom and the whole line of glass shoved up to close the opening.

Formerly, all window glass, except plate glass, had a slight bow or curve but flat glass is now used almost exclusively. Although it is of little importance which side of the old-type curved glass is placed upward, it should all be laid one way. Nearly all gardeners, however, place it with the bow or hump side uppermost. Double strength glass is preferable to single-strength, as it is less subject to breakage in handling. Grade B glass is most commonly used for glazing hotbed sash, but should be free from blisters.

CLOTH COVERINGS

In the southern sections, where the climate is mild and cloth coverings are largely used, the beds are usually constructed 12 to 14 feet in width and with a ridgepole supported on stakes about 30 inches high through the center of the bed. The muslin or light canvas used for the cover is sewed together in a large sheet and is fastened to the ridgepole by tacking thin strips of wood such as plaster lath or lattice strips on top of the sheet and to the ridgepole. The edges of the sheet are generally fastened to strips of wood running the full length at each side of the bed, and so arranged that the sheet can be rolled up on them (fig. 17).

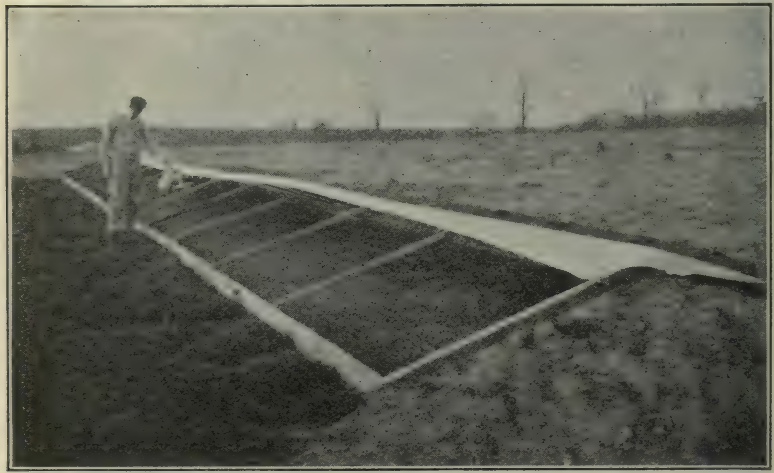

FIGURE 17.—Cloth-covered tomato-plant bed in eastern Texas. The plant beds are located directly in the field where the tomato crop is to be grown for convenience in transferring plants from the bed to the open ground.

Rafters consisting of ⅞- by 3-inch or ⅞- by 4-inch strips are nailed to the ridgepole and to the sides of the bed at intervals of 3 or 4 feet to support the cloth; the cloth is carried on these rafters when it is rolled up for ventilation. At the ends of the bed the cloth is fastened by loops of string hooked over nails. Marsh hay, light straw, or pine straw is often spread over the cloth during periods of cold weather. Beds containing tender plants, such as tomatoes, are frequently protected successfully for short periods with a temperature of 20° F. by this method of covering.

There are processes for treating cotton sheeting to make it waterproof and to preserve it, but, as a rule, a good grade of unbleached muslin without treatment is satisfactory. Preservatives may add to the life of the covering material, but if the muslin is taken off the plant beds promptly when the plant-growing season is over, rolled while dry, and stored in a dry place, it will last for several years.

Linseed oil, or any paint containing linseed or other drying oils, should not be used for waterproofing plant-bed covers as the oil paints rot the fabric and cause it to crack and break. A mixture consisting of 2 to 3 pounds of melted paraffin, one-half pound of melted beeswax, and 1 gallon of benzine applied to the cloth either as a spray or with a brush will act as a filler to make the fabric waterproof and at the same time preserve it. There are on the market preparations used for waterproofing tents and canvas generally which can be used for making ordinary heavy unbleached muslin both waterproof and windproof.[3]

SUBSTITUTES FOR GLASS AND CLOTH

Numerous substitutes for glass and cloth as coverings for hotbeds and coldframes are on the market, but many unwarranted claims are made concerning the effect of these substitutes on plant growth. Tests made in 1928 and 1929 at the Ohio Agricultural Experiment Station showed that while a good grade of clear glass transmits over 95 percent of the total light, certain glass substitutes transmitted as little as 25 percent and none of those tested more than 60 percent of the total light. Although these particular glass substitutes transmitted only 25 to 60 percent of the total light, they did transmit an appreciable percentage of ultra-violet light that does not pass through common glass. In ordinary plant-growing operations, however, the transmission of ultra-violet light is of no recognizable benefit, and the decreased transmission of total light is a definite disadvantage. The Ohio tests showed that in all cases better plants were grown under plain glass than could be grown under any of the glass substitutes.

CARE OF HOTBEDS AND COLDFRAMES

Regardless of the method of securing heat, the ventilation, watering, and general care of the hotbed or coldframe are of vital importance. The temperature of a manure-heated bed will usually run fairly high at first, and planting should be deferred until the temperature begins to decrease. The only safe procedure is to bury a thermometer bulb in the soil of the bed and delay planting until the temperature reading is 80° F., or lower. A soil temperature of about 70° or 72° is about right for nearly all early plants. However, it will be safe to plant the seeds when the temperature is slightly below 80°, for it will gradually decline as the fermentation of the manure diminishes. With bottom heat, such as is furnished by fermenting manure or pipes buried in the soil, the germination and early growth of the plants will be very rapid, and unless frequent attention is given to ventilation, the plants are certain to make a soft growth. In the manure-heated bed there is a constant supply of extra heat which can be controlled only by ventilating the bed. With a pipe- or furnace-heated bed, and where electric current is used, the bottom heat can be controlled almost at will.

Different crops require different temperatures and treatment; the temperature that gives best results for starting peppers and eggplant, for example, would be too high for tomatoes and much too high for cabbage, cauliflower, and lettuce. The desirable temperatures at which to grow the plants will be discussed later under the various crops.

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[3] Farmers' Bulletin 1157, Waterproofing and Mildewproofing of Cotton Duck.

VENTILATION

In ventilating the hotbed or coldframe during windy weather, care must be taken to raise the sash or cloth covering on the side opposite from that from which the wind is blowing so as to avoid a direct draft upon the plants. In the sash-covered bed, this is accomplished by lifting the sash on either side, or at the bottom or top, as the direction of the wind may require. Small pieces of boards or blocks of wood with notches cut in them are usually employed to support the sash. In some cases wires are stretched lengthwise of the beds on top of the sash to prevent them from being blown off during storms.

Where cloth or muslin coverings are used, ventilation is obtained by rolling them up a part or all of the way to the ridge of the bed, as shown in figure 17, or by propping them up in places by means of short pieces of lath. Special protection is provided during short periods of extremely cold weather by covering the beds with hotbed mats or with a thin layer of straw or pine straw that must be removed when the weather clears and the temperature rises. The straw can be removed from the glass or cloth covers by first using a wooden rake and then a broom to complete the cleaning.

In order to secure the greatest possible benefit from the sunlight, the glass or whatever covering is used should be kept thoroughly clean. Dust settling on top of the glass will frequently cut out 25 to 30 percent of the light. For that reason the glass should be frequently cleaned with brooms or water from a hose. The best of plant-bed coverings exclude considerable light, and every precaution should be taken to keep this exclusion to a minimum.

Coldframes are managed in practically the same manner as hotbeds in respect to ventilation and protection from sudden changes in temperature. As a rule, somewhat lower temperatures are maintained in coldframes than in hotbeds, but they require close attention on extremely bright days and during changeable weather. Clouds temporarily obscuring the sun will frequently cause a lowering of the temperature in the frames of from 12° to 15° F. Toward the end of the plant-growing period the sash or cloth coverings may be kept partly open at all times and finally be removed altogether to adapt the plants to outside conditions.

WATERING

Early in the season, extreme care is necessary in watering hotbeds and coldframes, because excessive watering is almost certain to cause damping-off of the plants. More water is required during bright, windy weather than when it is calm or cloudy. Watering should be done only at times when the beds may be safely opened without chilling the plants. Losses from damping-off can be largely prevented by careful watering and close attention to ventilation. Overheating of the beds is disastrous and results in the production of poor plants. Sufficient ventilation, especially toward the end of the period that the plants remain in the beds, with a somewhat sparing application of water, will produce plants that will withstand transplanting to the field with few losses.

The process of "hardening", as applied to plants grown under cover, consists of gradually tempering them to open-air conditions by checking their growth, but taking care to avoid stunting injury. Certain plants, especially eggplants, should be checked but slightly, if at all, for if their stems become tough and woody they are practically worthless for planting. Tomato plants will stand considerable checking but are injured if the process goes too far. Light watering usually aids in the tempering process; however, enough water must be applied at all times to prevent wilting. Excessive ventilation and windy weather are always accompanied by high evaporation and make extra care and more frequent watering necessary.

Plants grown to marketable stage in hotbeds and coldframes require somewhat different handling as to temperature and watering than do those that are to be transplanted to the open ground. With those that remain in the beds the hardening process is not used, and the plants are kept growing uniformly and usually as rapidly as possible without producing a soft growth. This is accomplished by careful regulation of the temperature and by the application of water in quantities that will maintain an optimum growth condition in the soil. In the growing of plants for transplanting, a period of relatively high temperature at first, followed by a declining temperature and the application of practically no artificial heat toward the end of the period, is ideal. In the case of the crop that is matured in the beds, the most satisfactory results are obtained with a continuous mild heat without excessive changes in temperature.

GROWING EARLY PLANTS

Plants that are normally grown under protection for early transplanting to the garden and truck fields may be classified into two general groups according to their temperature requirements. In the first group are those requiring a relatively low temperature; and in the second group are those requiring a somewhat higher temperature. Among the most important of the lower temperature plants frequently started indoors and transplanted are lettuce, cabbage, cauliflower, and broccoli. The crops requiring a somewhat higher temperature include tomatoes, peppers, egg plants, muskmelons, summer squashes, celery, and cucumbers. There are, however, within these groups certain very important crop-requirement differences that are briefly discussed in the following paragraphs.

TOMATOES

Tomato seed germinates readily at a soil temperature between 68° and 75° F., but when the seedlings appear aboveground the temperature should be lowered slightly to prevent weak and spindling plants. The time required for germination of tomato seed depends to some degree upon the viability of the seed itself, but good seed will germinate in 3 to 5 days at a temperature of 72° to 75° and in 5 to 8 days at temperatures from 65° to 70°. A soil temperature of about 62°

to 65°, with plenty of light and moderate watering, will usually produce good stocky seedlings, but the air temperatures should not be allowed to go much above 70° at any time. Plants grown in this manner will usually be ready for transplanting from the seed-trays or from the hotbed to the coldframe in 14 to 20 days after the seed is sown. If the seed is sown rather thinly and the plants do not crowd in the seed bed nothing is to be gained by extra-early transplanting to the coldframe. Plenty of ventilation and care in watering will generally obviate losses of the plants from the disease known as damping off.

Early-tomato growers of eastern Texas and Mississippi sow the seed in hotbeds and transplant the seedlings to cloth-covered coldframes located directly in the field where the crop is to be grown. As a rule one plant bed measuring about 12 by 60 feet (fig. 17) is provided for each acre of tomatoes to be planted.[4]

The plants are spaced about 4 inches apart in each direction in the coldframe, and when the time comes for setting them in the field a knife or a trowel is run between the plants in each direction and they are lifted and transported to the field with blocks of earth about their roots.

In sections where tomatoes are grown largely for the cannery, the seed is sown rather thinly in the seed beds, and after 4 to 6 weeks, or when the plants attain a height of 4 to 6 inches, they are moved directly to the fields. This method involves less labor than transplanting the plants from the seed bed to coldframes and later to the field, but does not give as desirable plants for early setting.

PEPPERS

Pepper seed is rather slow to germinate, usually requiring from 12 to 15 days at a soil temperature of 70° to 75°. Following germination the soil temperature should be lowered to 65°, or not over 68°, in order to produce stocky plants. The air temperature following germination should be kept between 65° and 75°. The same precautions as to watering and ventilation should be taken with peppers as with tomatoes. The danger of damping off can be largely eliminated by avoiding excessive watering and at the same time providing plenty of ventilation. The pepper seedlings will be ready for transplanting from the hotbed to the coldframe in 24 to 30 days after the seed is sown. Under the best conditions and where the seed germinates in a relatively short time the plants may be ready for this transplanting in 18 to 20 days after seeding. After being transplanted, the pepper plants should be carefully watched, and when first transplanted they should be partially shaded to prevent wilting. Following this the temperature of the coldframe should be between 70° and 75° during the daytime and not lower than 60° at night. In removing the pepper plants from the coldframe to the garden or field, they are blocked and a cube of soil carried with them to their permanent location.

EGGPLANTS

The eggplant is one of the most difficult vegetables to handle, especially during its early stages. The seed germinates somewhat slowly even at a soil temperature slightly above 70° F. Extreme care must be taken to keep the eggplant seedlings growing uniformly from the very start, for if the plants become checked and the stems hardened or woody, they are considered practically worthless for planting in the field or garden. As a rule the seedlings will be ready to transplant from the hotbed to a well-protected or warm coldframe in about 3 or 4 weeks after the seed is sown. In the coldframe the plants should be set at least 5 inches apart in each direction in a soil that is well fertilized and that contains an abundance of well-rotted, screened manure. At no time should the plants be subjected to strong drafts of cold air or to low temperatures. Excessive watering of the plants both in the hotbed and in the coldframe must be avoided. On the other hand, the soil in which the plants are growing should never be allowed to become too dry, as this is certain to result in a stunting of the growth of the plants. In moving the plants from the bed to the field they are blocked, and a large cube of earth is carried with them. The soil about their roots should be fairly well watered a few hours before the plants are to be lifted. Throughout the handling of the plants, extreme care must be taken as otherwise they will not grow in a satisfactory manner in the field, regardless of the attention that is given them after they are set out.

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[4] See Farmers' Bulletin 1338, Tomatoes as a Truck Crop.

SUMMER SQUASHES

Under most conditions the seed of summer squashes is planted directly in the hills where the crop is to be grown. Where extreme earliness is desirable, however, the plants may be started in heated plant houses or in hotbeds, inverted pieces of sod, berry boxes, paper bands, or flowerpots being used for the purpose. The seed of squashes will germinate in about 2 days at a soil temperature of about 75° F. After the seeds have germinated, the temperature should be lowered somewhat in order to keep the plants short and stocky. Where squashes are started indoors it is customary to plant six or seven seeds in each container; then, when the seedlings are well established, thin them to three plants. After the seedlings have formed the first true leaf they can be moved to a well-protected coldframe, where the plants may be held at a temperature of 60° to 70° until time to set them in the garden or truck field. By starting the plants in hotbeds and coldframes, most of the difficulty with the striped and spotted cucumber beetles can be avoided. By this process the first of the crop can be ready to market from 1 to 2 weeks earlier than when the seed is planted in the open.

CUCUMBERS

The growers of early cucumbers in the Norfolk-Portsmouth, Va., district follow the practice of sowing their cucumber seed in specially heated beds with the soil temperature between 80° and 85° F. The seeds are sown fairly thick in rows, and, as a rule, the seedlings will appear above ground within 30 to 36 hours. In approximately 72 hours after sowing, the seedlings are ready to be lifted and placed in 5-inch flowerpots, 7 to 10 seedlings being planted in each pot. These pots are then placed in the bench of a greenhouse at a temperature of 70° to 75° during the day and not lower than 60° or 65°

at night, and the plants are carefully watered and ventilated for about 4 weeks, when they will have formed about 3 or 4 true leaves. During this period the plants are thinned to about 3 in each pot. They are then in proper condition for setting in outdoor frames.[5]

In moving the plants from the greenhouse to frames or to the fields the soil in the pots is given a fair watering, then the plants are carried direct to the field, where they are loosened from the pots and set in the ground with the ball of earth about their roots. Cucumbers may be grown in the hotbed in quart berry boxes, paper bands, or flowerpots, the seed being sown directly in the containers, which are filled with a good grade of sifted soil. The corners of the boxes should be slit with a knife and the boxes removed when the plants are set in the ground.

MUSKMELONS

Muskmelon seedlings are frequently started in hotbeds in the same manner as cucumbers; however, it is not customary to start the seed in a special heated seed bed and transplant the seedlings, although this can be done safely. The rule is to use pieces of inverted sod, berry boxes, or paper bands and plant 10 to 12 muskmelon seeds in each container. After the seedlings become established they are thinned first to about 5 and later to 3 plants to each hill. Muskmelons require practically the same temperature conditions as cucumbers, and the methods of handling the plants and transferring them to the field are practically the same as those given for cucumbers and squashes. The advantages of starting the muskmelons indoors are earliness of fruiting and less liability to injury from the striped cucumber beetle. It is desirable to give the plants one spraying in the plant bed with bordeaux mixture before they are moved to the field.

LETTUCE

Lettuce is one of the more important garden crops that thrive under a moderately low temperature. The seed is one of the few that does not germinate readily when it is strictly fresh, and it should not be planted during the fall of the year in which it is produced. When growing lettuce plants indoors the usual practice is to sow the seed in boxes or trays filled with a good grade of garden loam which has been thoroughly mixed and sifted. Generally the seed will germinate in 4 to 6 days, and the plants will be ready for transplanting in 12 to 15 days. The seedlings can be transplanted from the seed trays or the hotbed to the coldframe either in other trays or direct to the soil of the coldframe. As a rule, the plants are spaced about 3 inches in each direction so as to give them enough room to develop and allow for the transfer of a fair-sized block of soil around the roots of the plants when they are taken to the garden or the truck field. Lettuce seedlings are subject to damping off in the seed bed, especially where the seed has been sown too thick. This difficulty can be avoided by thin seeding, careful watering, and plenty of ventilation, although the use of a mercury bichloride solution may be found advantageous in checking this disease.[6]

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[5] For further information see Farmers' Bulletin 1563, Cucumber Growing.

[6] For further information see Farmers' Bulletin 1371, Diseases and Insects of Garden Vegetables, and Farmers' Bulletin 1609, Lettuce Growing.

CABBAGE AND BROCCOLI

Early plants of cabbage and broccoli are frequently started in hotbeds or in well-protected coldframes. About 4 or 5 weeks are required from the time of sowing the seed to produce good cabbage or broccoli plants for setting in the garden. Where the seed is sown in the hotbed it will be necessary to transplant the seedlings to a coldframe because the temperature of the hotbed is too high for the production of good stocky cabbage or broccoli plants. The soil temperature of the seed bed should not be above 70° F. After transplanting to the coldframe the air temperature should be maintained at about 65° to 70° during the day and 55° to 60° at night; however, a drop in temperature to perhaps 45° for a short period as a rule will not greatly injure these plants. Repeated chilling or carrying the plants at low temperatures for a period of 2 weeks or more may cause them to bolt to seed after they are set in the field or garden. In sections of the country where the climate is fairly warm during the early spring a hotbed for starting the early plants will not be necessary; the seed can be merely sown in a coldframe or in a flue-heated bed similar to those used for starting sweetpotatoes. Fairly thin seeding will produce better plants than overcrowding the seedlings. The same general methods given for cabbage should be followed in the production of broccoli plants.

CAULIFLOWER

Cauliflower plants are decidedly more delicate in their habits of growth than those of either cabbage or broccoli, and for that reason require more careful handling. The main point in the handling of cauliflower plants is to keep them growing and to prevent checking or stunting during the time they are in the plant bed. In case the stems of cauliflower become tough or woody this stunting affects their future growth and usually results in the formation of small and inferior heads of cauliflower; therefore, cauliflower plants require a little higher temperature and closer attention than those of cabbage or broccoli. They also require very careful watering, because drying out will affect their growth and will have a tendency to cause them to be tough and woody. Besides having a uniform temperature maintained and being given proper ventilation, cauliflower plants should be given plenty of space, and when they are transplanted from the seed bed to the coldframe or other space where they are to remain until they are planted in the field they should be well shaded for a day or two. In being moved from the hotbed or coldframe to the field or garden, cauliflower plants should not be pulled, as cabbage plants frequently are, but should be lifted with considerable soil adhering to their roots. In case the soil should be dry at the time the plants are set out, they should be given a good watering as they are set. If possible, a calm, cloudy, moist day should be selected for setting the cauliflower plants in the field or garden.

CELERY

Celery seed is slow in starting, and the seed bed must be carefully watched to prevent drying out. Seed stored in a dry place usually retains its vitality for 4 or 5 years, but where old seed is used it should be carefully tested in advance of planting time. Good, viable celery seed will germinate in 10 to 15 days at a soil temperature of about 63° to 68° F.; where the seed is sown directly in a hotbed the sowing should be delayed until the heat of the bed is well spent and the soil temperature has fallen below 70°. In the greenhouse a temperature varying between 60° and 70° is about right; where the seed is sown in flats a partially shaded location is desirable until the seedlings appear, after which full sunlight and a fair amount of ventilation should be provided.

In sections where muck or peat is available this material is largely used for starting celery plants. A seed bed consisting of 2 parts good garden loam, 1 part fine but sharp sand, and 1 part leaf mold or old decayed compost thoroughly mixed and sifted through a screen having four meshes to the inch will give good results. Watering is very important to keep the seed bed properly moistened and ventilation to avoid overwatering and the development of the damping-off disease. Thin seeding will aid very materially in the prevention of this disease, but careful watering and plenty of ventilation are also essential.

A few growers still double transplant early celery plants. The main or late crop, however, is grown from seedlings that are started in spent hotbeds or in coldframes, or from outdoor plant beds.

Celery belongs to the group of garden vegetables that thrives under relatively cool conditions, but recent experiments have shown that prolonged periods of low temperature during the plant-growing period is largely responsible for celery bolting or shooting to seed prematurely. Under normal conditions celery is a biennial and produces its seed crop the second season, but under certain conditions the plants shoot to seed during the first season and fail to produce an edible crop.

It has been a common practice among the northern growers of early-crop celery to start the seedlings in a greenhouse and transfer them to coldframes. In some cases the plants are held in the greenhouse for several weeks and then transferred to the coldframe where they are hardened at temperatures below 60° F., usually between 40° and 50°. If this hardening period extends beyond 2 weeks at a temperature below 60° a large percentage of the crop is fairly certain to bolt to seed before it has reached a marketable stage. It is not necessary to use low temperatures for hardening the plants, as this can be accomplished by light watering. In case the plants are subjected to temperatures below 60° in order to harden them the treatment should be given for a week or 10 days only, and during that time water should be used sparingly. Celery plants grown in the open during the early part of the season may go to seed if relatively low temperatures prevail during the plant-growing period. High temperatures during June and July may, however, correct this difficulty.

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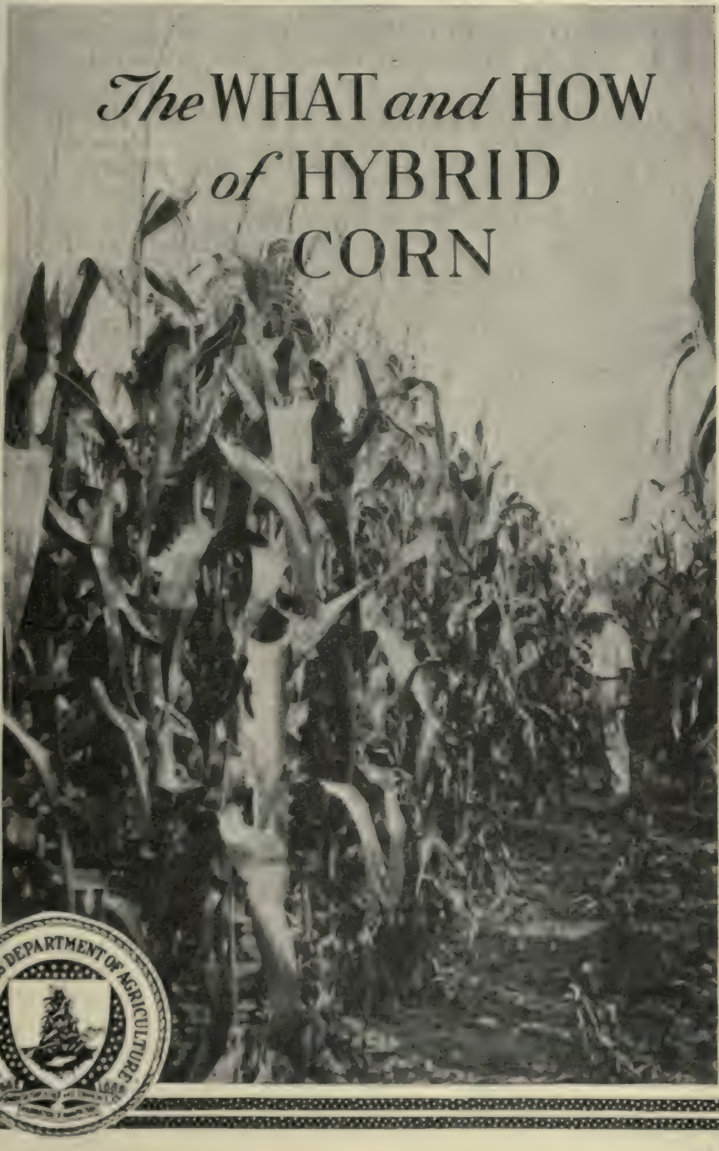
FARMERS' BULLETIN No. 1744

The WHAT *and* HOW *of* HYBRID CORN



HYBRID SEED CORN is the first-generation cross or hybrid involving two or more inbred strains of corn.

Individual hybrids are just as definite as individual varieties.

A good hybrid is a very efficient kind of corn the plants of which are uniform for their good characteristics. It therefore averages better in acre yield and quality than the best open-pollinated varieties.

A poor hybrid is not efficient. The plants are uniform but uniformly poor, and using seed only because it is " hybrid " may result in low yields or unmerchantable corn, with consequent loss.

The full value of hybrid seed (i. e., the seed resulting from cross pollination of two unrelated stocks) exists only in the first hybrid generation. Seed grown from hybrid seed will yield less than the first generation and may be inferior to that of ordinary varieties.

Hybrids are just as definitely adapted to various localities as are varieties, and hybrid seed corn should be used only when it is known that the particular hybrid is adapted and productive in the particular locality.

Good hybrid seed corn is now available only in certain localities. Consult the State agricultural experiment station or the State extension service regarding their recommendations as to seed corn.

Washington, D. C. **Issued January 1935**

THE WHAT AND HOW OF HYBRID CORN

By FREDERICK D. RICHEY, *chief, Bureau of Plant Industry*[1]

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INTRODUCTION

THE DEVELOPMENT of hybrid corn has come about as a direct result of advances in the knowledge of genetics, the science of heredity. The practical application to the art of corn breeding of the principles learned through these advances is made feasible by a combination of three conditions that obtain only with corn and corn growing: (1) Pollination in corn can be controlled easily by pulling the tassels, before they shed pollen, from those plants that it is not desired to have function as male parents; (2) an individual corn plant produces a large number of seeds; (3) only a small quantity of seed is needed to plant an acre. These facts make it possible to produce hybrid seed corn anew each year at a relatively low cost per acre to be planted. This low cost of hybrid seed is combined with the advantages of large yields and superiority in quality and in ability to withstand storms, disease, and other vicissitudes. Hybrid corn is a new development, and consequently there is an ever-increasing demand for information on what hybrid corn is, and how it is produced.

Possibly the simplest way to give a general idea of what hybrid corn is, is to compare it to the mule. A corn hybrid, in fact, has many things in common with the mule. A mule is the first-generation hybrid between the mare and the ass, and partakes of the better qualities of both parents. It does not reproduce, but must be produced anew each generation for its value in itself, not for reproduction. A corn hybrid is the first-generation hybrid between two strains of corn. Its value is for seed in the production of a crop of commercial corn. This corn will grow, but cannot be used for seed without a loss in yield in the succeeding generations. A corn hybrid, then, like the mule, must be produced anew each generation for its value in itself, not for reproduction. During that generation good hybrids produce larger acre yields of high-quality corn than do the best commercial varieties. Finally, neither all mules nor all corn hybrids are efficient.

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[1] Formerly principal agronomist in charge of corn investigations, Division of Cereal Crops and Diseases.

REPRODUCTION IN CORN

In order to understand just what hybrid corn is, it is necessary to know how the corn plant reproduces. Each kernel of corn results from the fertilization of an egg by a sperm. The egg is at the base of the silk, and the sperm is in the pollen. It is therefore customary to speak of the plant on which the ear is produced as the female parent and of the plant or plants supplying the pollen as the male or pollen parents.

Ordinarily, corn is wind-pollinated, the pollen being carried at random through the air and some of it falling on receptive silks. There it germinates, sending down a pollen tube through which the sperm reaches the egg to effect fertilization. Selecting an ear from a good plant, accordingly, is selecting a good female parent only. Each kernel on the ear may have been pollinated from a different male parent plant. It is this condition that has made it impossible to select varieties of corn that breed true for any but the most simple characters. The breeder sees only what the female parent is like; the pollen parent is unknown. Moreover, many characters are not expressed in the hybrid condition. Thus, the ears of a true-breeding white corn that have been pollinated by a red corn are white, but if such cross-pollinated white seed is planted, all the ears will be red. Then, if this red corn is planted, about one-fourth of the resulting ears will be white and three-fourths red.

In spite of these difficulties, the better varieties of corn have been developed to a relatively high state of productiveness by careful selection over a long period. That is, by selecting seed only from the most productive plants each year, the unfavorable characters have been reduced to such a small proportion that any one is expressed but seldom. Always, however, even in the best varieties, most of the plants are below par because of one or more unfavorable characters, and some of the plants are barren or produce only nubbins because of serious inherited faults.

SELECTING INBRED STRAINS

The development of a good hybrid comprises (1) obtaining the best possible inbred lines or strains and (2) finding those that can be crossed into the best hybrid combination of one kind or another for commercial utilization. The final hybrid is thus the product of many years' careful selection and experimentation. During this breeding period all pollinations are made by hand. Ear shoots are protected from stray pollen by being covered with small paper bags until after the silks emerge. Pollen from tassels that also have been protected then is applied to make the desired mating (fig. 1), and the pollinated ear shoot is again protected (fig. 2). In this way the parentage on both sides is definitely controlled.

In selecting inbred strains, good plants of one or more varieties of corn are self-pollinated, that is, pollen is placed on the silks of the same plant from which it came. The best of the resulting ears are planted, an ear to a row, and good plants within these rows again are self-pollinated, and so on for several generations. Each year, however, only the ears from the best plants from the best rows are selected for continuing the various strains.

With a continuation of this inbreeding there is a marked increase in the uniformity of the plants within any progeny row, although the differences from row to row are extreme. Some strains are discarded almost at once because of grossly unfavorable characters. Others are better and are continued. After some 5 to 7 generations of self-pollination the strains breed practically true for whatever char-

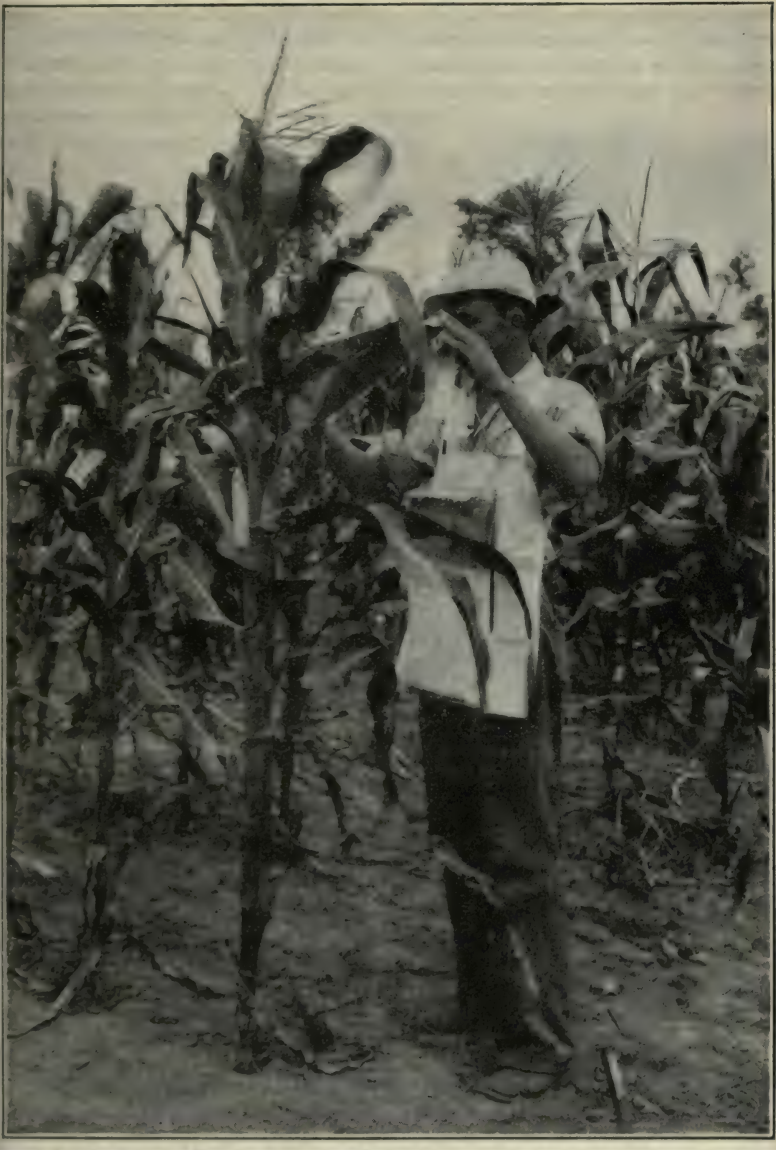

FIGURE 1.—Applying pollen from a selected plant to an ear shoot that was previously protected from stray pollen and will again be protected. (See fig. 2.)

acters they possess. Every plant of any strain is practically like every other plant. After this it is unnecessary to self-pollinate in propagating a strain. Pollination between plants of a strain is then essentially like self-pollination.

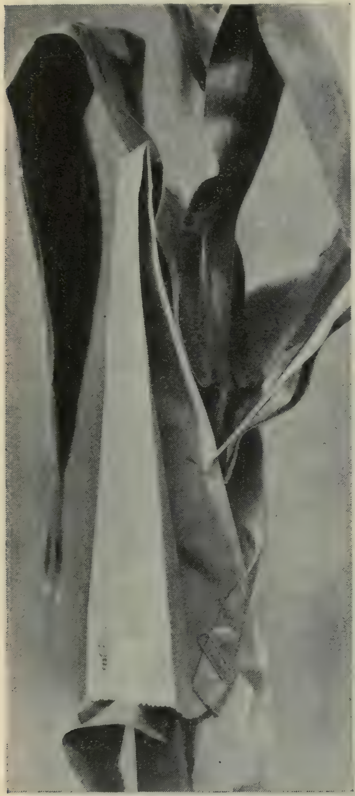

FIGURE 2.—Method of covering corn-ear shoots with paper bags after pollination from a selected plant, which insures against partial pollination by an unknown male parent.

So far, among the thousands of inbred strains that have been isolated in this way, none has been found which even approaches ordinary corn in size or production. Nevertheless, no two strains have exactly the same set of faults, and some of them have characters of outstanding value. Thus, some regularly produce long ears, others have stiff stalks or good roots or are resistant to heat, or cold, or disease and the like. It is the problem of the corn breeder to bring these good characters together in desirable combinations. It already has been noted that white corn crossed with red and planted will produce only red corn in what is known as the first hybrid generation; but white will recur in the following or second generation. Many characters are not expressed in the hybrid condition, and this is particularly true of characters unfavorable to growth and production. Consequently, when two inbred strains are crossed or hybridized, the better characters of both parents tend to be expressed in the first generation, just as the mule more nearly approaches the size of the horse and the stamina of the ass.

Because the inbred strains breed true, they provide the corn breeder with fixed material with which to work, the first he has ever had. The faults and virtues of the strains and of their hybrid combinations can be determined by actual test in successive years and under different conditions, with the knowledge that once hybrids are found that are good under several sets of conditions, they can be reproduced with certainty from year to year indefinitely.

FINDING GOOD HYBRID COMBINATIONS

To a certain extent the corn breeder can select inbred strains for crossing on the basis of his knowledge of their characters. Thus, strains with weak stalks, poor root systems or short ears in general must be crossed with strains having sturdy stalks, good root systems or long ears to provide a reasonable chance of having a good hybrid.

This will not always work, however, and beyond this he must rely on testing large numbers of hybrids to find those strains that combine best. The inbred strains producing the poorer hybrids are discarded. Those producing the best hybrids are again crossed and the hybrids tested more adequately. Eventually, through continued elimination and selection, a few lines that combine to advantage in several combinations are found. Finally, some 2 or 3 combinations that have been among the best in a given locality during several seasons are placed in commercial production.

DIFFERENT KINDS OF HYBRIDS

Inbred strains may be combined into several different kinds of hybrids. Thus the single cross or hybrid is between 2 inbred strains, the three-way cross involves 3 strains, the double cross 4 strains, and the top cross involves 1 inbred strain and 1 open-pollinated variety. Each of these has certain advantages and disadvantages or fits into the corn-breeding program in a particular way.

The simplest of these hybrids is the single cross, or hybrid between two strains. Thus, designating the female parent first in the customary way, B×A designates the single cross of strain B pollinated by strain A. The seed of the cross is that produced on the plants of strain B and usually will not appear noticeably different from self-pollinated seed of B. The vigor of hybridity becomes evident, however, shortly after germination begins if the crossed seed is planted.

The three-way cross is the hybrid of a single cross between two inbred strains and a third inbred strain. It is customary to use the single cross as the female and the third inbred strain as the male parent in producing a three-way cross. Thus, (B×A)×C designates the single cross B×A pollinated by strain C. The crossed seed produced on the vigorous B×A plants is superior in quality and quantity to that produced on inbred plants as in single crosses.

Double crosses are hybrids between two single crosses, involving four different inbred strains. Thus, the double cross or hybrid (B×A)×(C×D) designates the hybrid of the single cross B×A pollinated by the single cross C×D. Here, both the male and female parent plants are vigorous hybrids. The seed quality and production are high, and there is every possible assurance of abundant pollen from the male parent, which is not true when this parent is an inbred strain.

The cross of a commercial variety and an inbred strain has been variously designated as a top cross, inbred-sire cross, and the like. In limited experiments, some such crosses have yielded more than ordinary varieties but less than comparable double crosses.

The make-up of double-cross hybrid seed is illustrated in figures 3 and 4. The four ears labeled B, A, C, and D (fig. 3) represent the product of the inbred parent lines. If these are self-pollinated they will reproduce ears like those shown year after year. Seed from ear B, however, when pollinated with pollen from the plant producing A, produces the single cross B×A, shown immediately below its parents. Similarly the single cross C×D is produced from seed on ear C that was pollinated by pollen from plants producing D ears. The ears on the B×A plants, cross pollinated by pollen from C×D plants, then provide the first-generation seed of the

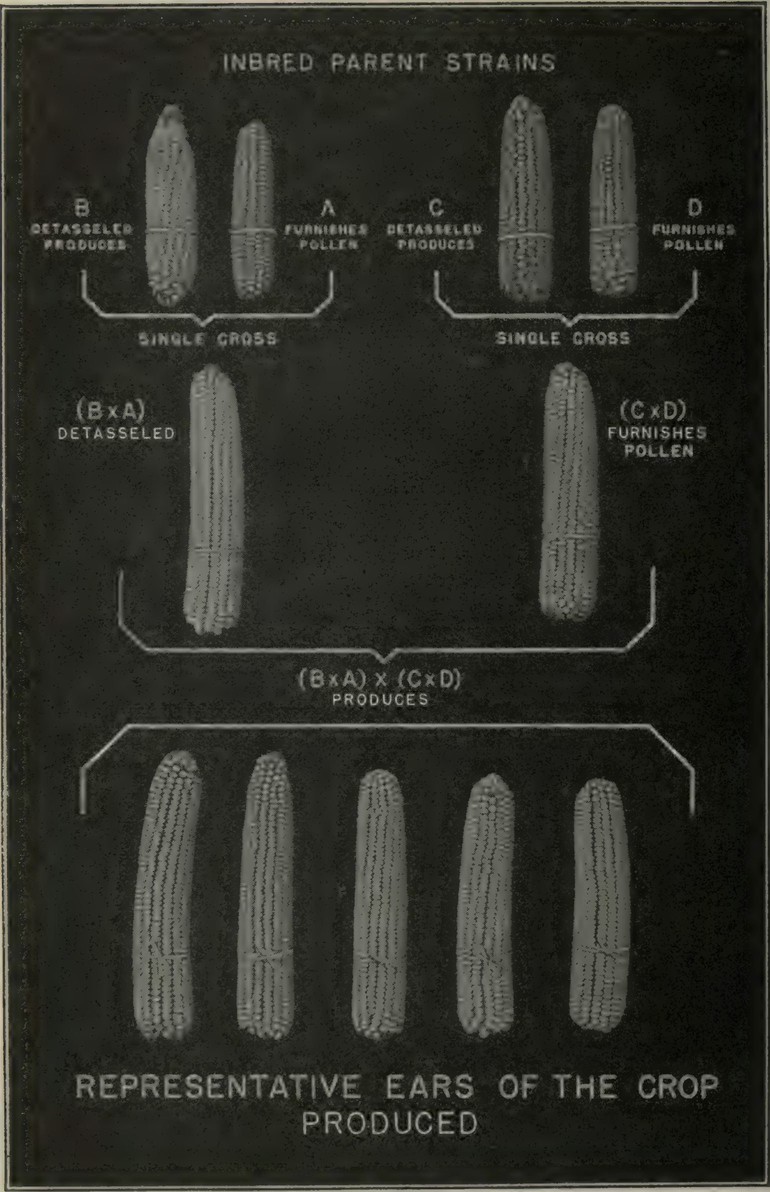

FIGURE 3.—Method of producing double-cross hybrid seed corn and representative ears of the crop produced from hybrid seed.

double cross (B×A)×(C×D), which is used in growing the ordinary corn crop. The ears at the bottom of figure 3 represent what is produced in such commercial fields. The ears produced on the C×D plants grown to furnish pollen are used for feed or commercial corn. The seed from these ears may be planted to produce pollen-furnishing plants for another crossing block the next year. Such seed is referred to as advanced-generation seed and is equal to first-generation seed for producing pollen parent plants, but these

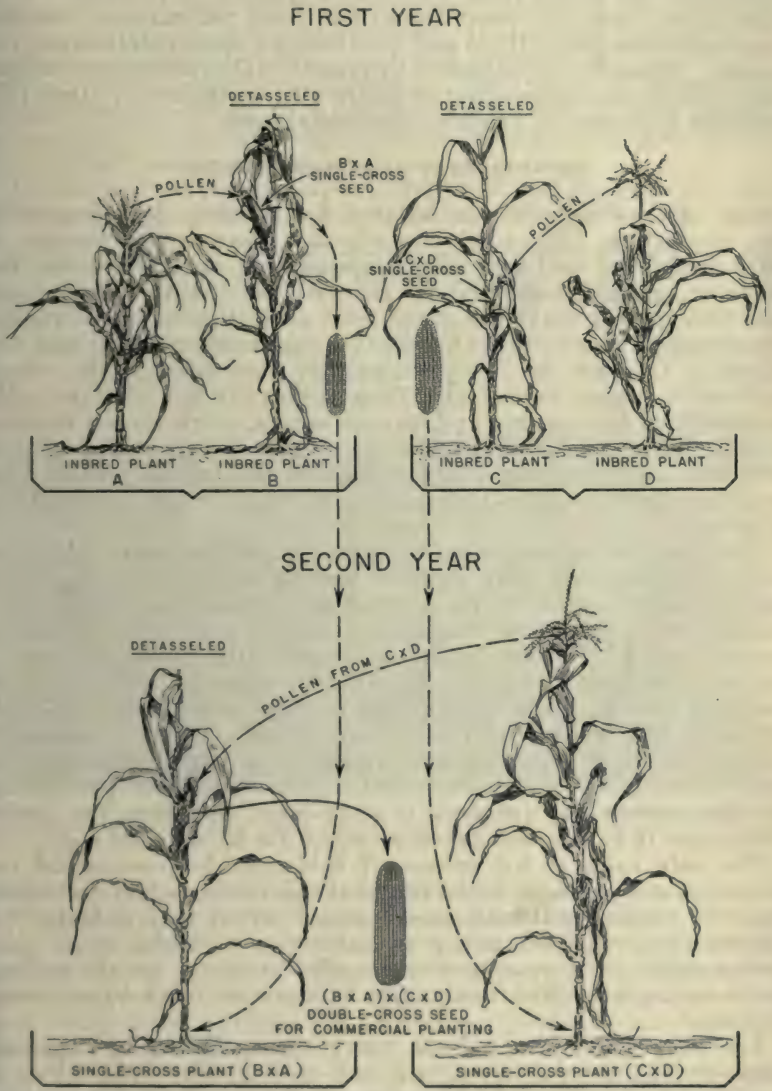

FIGURE 4.—Diagram of method of crossing inbred plants and the resulting single crosses to produce double-cross hybrid seed. A field grown from such hybrid seed is shown on the cover of this bulletin.

will yield on an average only about two-thirds as much grain as the first generation.

The situation is perhaps clearer from figure 4, which shows the system of crossing beginning with the inbred plants. Plant B is pollinated with pollen from plant A and plant C is pollinated with pollen from plant D. Seed from these cross pollinations produces the single-cross plants B×A and C×D shown immediately below the parents. Plant B×A pollinated by plant C×D produces the double-cross hybrid seed represented in figure 4 by a single ear. It is this seed that is planted to produce commercial corn.

ADVANTAGES OF DIFFERENT HYBRIDS

Any of these hybrids can be used for planting for commercial corn production. The single cross is at a disadvantage because of the low yield of seed and its consequent high cost. Moreover, the irregular size and shape and the generally small kernels of present field-corn inbreds make the commercial utilization of single crosses impractical. Single crosses produce the most uniform plants and ears of any of the hybrids. They accordingly have special value where uniformity is most important. Thus uniformity is highly desirable in sweet corn for canning, and, to some extent, single crosses between inbred strains are being used commercially for this purpose. In field corn, however, three-way and double-cross hybrids will be used unless much better inbred strains are developed than are available at present.

The three-way cross has no particular advantage over the double cross. It is slightly more uniform but not importantly so. Probably the main reason for the production of three-way crosses commercially has been that it was easier to find 3 reasonably good inbred strains than 4. The serious disadvantage of the three-way cross is that an inbred strain must be relied upon to supply pollen for the cross. Unless an inbred that can be counted on for this purpose is available, the three-way cross is impractical. Even a reasonably good pollinating strain requires a somewhat larger proportion of male parent plants with a somewhat higher cost of seed production. For the present and for some time to come, therefore, the double cross seems to be the most practical source for hybrid seed corn.

The only value of top crosses of field corn for commercial use at present appears to be in the fact that it is easier to find one inbred that will combine well with some standard variety than to find 3 or 4 inbreds that will produce a good three-way or double cross. Experimentally, top crosses provide an efficient means for the preliminary testing of inbred strains for later use in other hybrid combination.

The user of hybrids need not worry about whether he is getting single-cross, three-way cross, or double-cross hybrid seed, if it is of good quality (quality including size and shape suitable for machine planting) and if it has a definite record of productiveness in his community. The producer of hybrid seed will be governed largely by his individual facilities and the inbred strains that are available to him.

PRODUCING HYBRID SEED CORN

Regardless of what kind of hybrid seed is involved, only the first generation of the hybrid should be sold or used for commercial planting. Only from this generation, i. e., the seed that was actually cross-pollinated by an unrelated strain or hybrid, is the maximum benefit of hybrid vigor to be obtained. The second generation of any double-cross hybrid, that is, the seed produced by the first generation, may be expected to yield from about 10 to 25 percent less than the first generation, the exact decrease depending upon the particular hybrid. It is this fact that necessitates producing the hybrid anew for each season's use.

Hybrid seed is produced for commercial use by growing rows of the two parents in an isolated field and detasseling the plants of the female parent. In general, a field for this purpose should be not less than 40 rods from other corn unless there are buildings, trees, or other barriers between, or unless the two fields do not tassel at the same time. From 2 to 4 rows of the female parent can be planted to every row of male parent. An isolated crossing block at the Iowa Agricultural Experiment Station, with 4 rows of the female parent (detasseled) to 1 of the male parent, is shown in figure 5. If an inbred strain is to furnish pollen, it is safer to plant not more than 2 rows of the female parent. If a vigorous hybrid is to be the male parent, 4 rows of the female parent can alternate safely with 1 row of the pollen parent in the Corn Belt. As the seed comes only from the female-parent rows, this is a good reason for using a vigorous male parent.

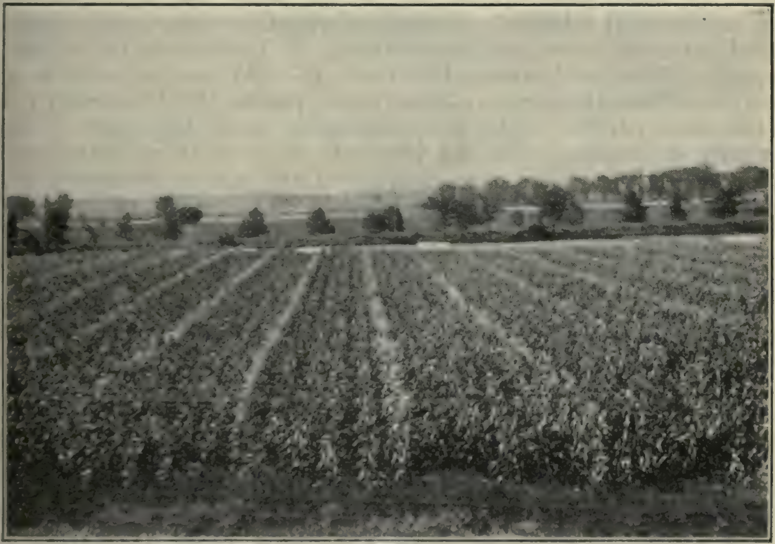

FIGURE 5.—An isolated crossing plot at the Iowa Agricultural Experiment Station. The tassels have been pulled from female parent plants growing in four-row blocks, the tassels being left in every fifth row to supply all the pollen in the plot.

DETASSELING AT BLOSSOMING TIME

During blossoming time the field is gone over at regular intervals, and all tassels are pulled from the female-parent plants before they shed pollen. With few exceptions the tassels emerge enough so that they can be seen before they begin to shed. A quick upward pull at this time takes the tassel out cleanly without damage to the plant. Tassels pulled too early are likely to bring with them part of the top of the plant, with some damage. On the other hand, it is not safe to wait too long lest the tassels begin to shed before they are pulled. Therefore, it is necessary to go over the field practically every day until detasseling is completed.

For large-scale hybrid-seed production at least two of the inbred strains and primary single crosses also are produced in isolated fields. In small-scale production, as for home use, it is probable that stocks of the inbred parents and single crosses can be maintained more easily by hand-pollinating. A 1-acre unit for producing seed of the double cross (B×A) × (C×D) may be taken as an example. With three rows of the female parent B×A to every row of the male parent C×D, one man easily could take care of the necessary detasseling. On the very safe basis of an estimated acre yield of 40 bushels, the three-fourths of the plants detasseled will produce 30 bushels of double-cross seed. With a loss of one-third in culling, this will provide a minimum of 20 bushels, or enough to plant between 120 and 140 acres from a 1-acre detasseled crossing plot.

Presumably there will be specialized production of the parent strains and single crosses. That is, farmers desiring only to produce seed for their own commercial planting or for sale will be able to buy the single-cross seed needed. Others may wish to maintain their own stocks of parent strains and produce their single crosses. On the basis of 1 acre for producing double-cross seed, some 200 or fewer pollinations would be needed. Thus, 20 plants of each of the parent strains would be ample to maintain these stocks. An additional 90 plants of strain B to be cross-pollinated by strain A, and 30 additional plants of strain C to be pollinated by strain D, would supply enough single-cross seed for the acre, with a liberal margin of safety.

YIELDS OF HYBRIDS

It is clear that the labor and expense of hybrid-seed production can be justified only if the hybrids will yield materially more than the best open-pollinated varieties. The Iowa corn-yield test has been conducted for several years by the Iowa Corn and Small Grain Growers' Association in cooperation with the Iowa Agricultural Experiment Station and the United States Department of Agriculture. Upon payment of the required fee, anyone can enter his corn and have it tested in 1 or more of the 12 (reduced to 9 in 1933) districts into which the State is divided. Entries are divided into two classes, open-pollinated and hybrid. These are tested in such a way that the yields are entirely comparable. Because of the open competition, yields from this test afford excellent evidence of the extent to which hybrids are superior to the better varieties of open-pollinated corn.

In the 92 district tests of the Iowa yield test from 1926 to 1933, inclusive, the average yield of all hybrid entries exceeded that of all open-pollinated entries by 9.3 percent. Many of these hybrids had been tested in only a preliminary way, or not at all, before entry. Beginning in 1933, a separate class for "regular hybrids" was established, comprising hybrids that were in commercial production in the State, in contrast to those that were only in an experimental stage. The number of open-pollinated and of regular-hybrid entries in 1933 and the average acre yield in each of the nine districts, together with the excess yield of the hybrids, is shown in table 1. The average excess yield of the regular hybrids was 7.9 bushels, or 12.5 percent.

TABLE 1.—*Acre yields of open-pollinated and regular hybrid entries in the Iowa corn-yield test in 1933*

District	Entries		Acre yield		
	Open pollinated	Hybrid	Open pollinated	Hybrid	Difference
	Number	*Number*	*Bushels*	*Bushels*	*Bushels*
1	13	6	58	69	11
2	10	6	65	71	6
3	10	6	87	93	6
4	8	5	40	49	9
5	9	6	63	76	13
6	8	5	59	67	8
7	12	4	67	73	6
8	11	4	58	63	5
9	13	5	74	81	7
Average			63.4	71.3	7.9

These results are not unique. Similar differences in favor of hybrids could be shown for practically all of the Corn Belt States and some others. It seems enough here, however, to present these data as typical of the larger acre yields that may be expected from good hybrids in comparison with the better open-pollinated varieties. In general, the excess yield of the hybrid will tend to be less when yields are low. In other cases, however, the superiority of the hybrid may be much more. This is particularly true when the hybrid is resistant to storm damage, smut, or some other condition to which the open-pollinated corn is more susceptible.

With a bushel of seed corn planting 6 to 7 acres in the Corn Belt, it is conservative to estimate an increased production of 40 to 50 bushels from each bushel of hybrid seed. As this larger yield is produced for the same cost except for seed and harvesting, the use of hybrid seed offers farmers a way of materially decreasing the cost of production, when only yield is considered. Even the present-day hybrids have other advantages, and the corn-breeding programs under way definitely promise further advances.

Hybrid corn produces its larger acre yield to a considerable extent because all of the plants do their part. There are very few barren plants in a field of hybrid corn, and a much smaller percentage of nubbins. This not only increases the yield but also the ease of harvesting. Cost of husking hybrid corn is still further reduced by its ability to stand up better. Some of the earlier hybrids did not have this advantage, but most of the more recently developed hybrids are markedly resistant to lodging. Hybrids also bear their ears at a much more uniform height than open-pollinated corn, further adding to the ease of harvesting. All in all, it seems likely that the increased ease of harvesting all the crop will compensate for the cost of harvesting the extra yield, leaving the larger cost of the seed as the sole charge against the larger yield.

It is undesirable at this time to overemphasize other possible advantages of hybrids. Their production is relatively new, and time has not permitted bringing many desirable characters together into a single hybrid. Progress already made, however, points to the certainty of breeding strains from which can be produced hybrids having resistance to smut, stalk and ear rots, cold, drought, and other vicissitudes. An example in this class is the Golden Cross Bantam, a single-cross hybrid, developed by the Indiana Agricultural Experiment Station in cooperation with the Bureau of Plant Industry. In 1933 this hybrid sweet corn produced a good crop in many localities in which fields of ordinary varieties produced nothing because of bacterial wilt.

NOT ALL HYBRIDS ARE PRODUCTIVE

It cannot be emphasized too strongly that not all hybrids are productive. The foregoing comparisons are based on the better hybrids. If one can know he is getting a better hybrid, that is all that is of interest. This fact must be known from definite knowledge of the previous performance or from the reliability of the source from which hybrid seed is obtained. The lowest yield in each of the six districts in the southern half of the Iowa yield test in 1931 was made by a hybrid entry. A grower buying hybrid seed just because it is hybrid has no assurance that he will get larger yields, and he may have to pay a tremendous penalty for growing it in getting a low yield or soft, unmerchantable corn.

It should also be emphasized that adaptation is just as important in hybrid seed corn as in ordinary varieties. Hybrids adapted to southern Iowa are too late maturing to be grown safely in northern Iowa. The fact that a hybrid is productive in Ohio is little evidence of its value in Missouri or Kansas.

Finally, hybrid seed corn will not produce large yields in spite of poor soil and poor culture. The plants are more efficient in general. But where fertility or moisture is available for an acre yield of no more than 20 bushels of corn, this condition is the limiting factor whether the seed is that of a variety or of a hybrid. The purchase of hybrid seed to plant on unproductive soil rarely will be profitable.

Good hybrid seed is simply a very efficient kind of seed corn that produces plants that are uniform for certain desirable characters. These plants average better than the plants of open-pollinated varieties. The plants of a poor hybrid likewise are uniform but uniformly poor. There is no magic in hybrid corn, and it should be used only when the value of the particular hybrid is known.

SOURCES OF HYBRID SEED

The purpose of this bulletin is to give information on what hybrid seed corn is and how it is produced. To advocate the immediate and general use of hybrids would be premature in many localities, inasmuch as hybrid seed or the parent inbreds are available in only a relatively few States at the present time. The United States Department of Agriculture and many of the State experiment stations, however, have corn-breeding programs aimed at the production of hybrid seed corn, and within a very few years such seed should be more widely available. Already several commercial seed companies are offering hybrid seed for sale, and some of the State experiment stations are distributing hybrid seed for trial and single crosses for the production of double-cross seed on the farms. Anyone interested in hybrid seed corn should consult his State agricultural experiment station or agricultural extension service for information on the availability of hybrid seed adapted to his locality.

The development of inbred strains for the production of hybrid seed is a more elaborate project than most farmers are justified in undertaking. Occasional individuals with the necessary time and facilities may be interested in this phase of corn breeding. It is suggested that such individuals obtain United States Department of Agriculture Bulletin 1489, Corn Breeding,[2] which contains a more detailed discussion of the principles and practice of this and other methods of corn breeding.

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[2] This bulletin may be obtained only from the Superintendent of Documents, Government Printing Office, Washington, D. C., for 25 cents a copy

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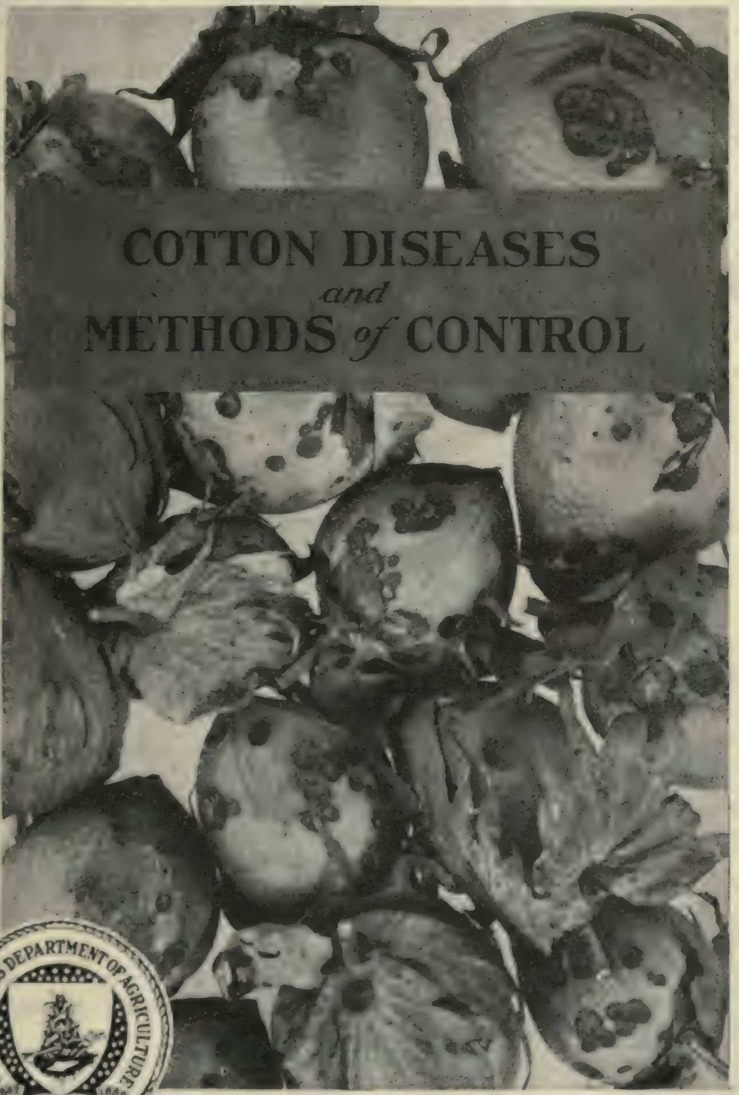
U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1745

COTTON DISEASES *and* METHODS *of* CONTROL



SUMMARY OF CONTROL MEASURES FOR THE MORE IMPORTANT COTTON DISEASES

Disease	Control measures
Root rot	Rotate with grain crops and subsoil land after grains are harvested. Apply organic manures in irrigated districts. Disinfect isolated centers of infection with ammonia or formaldehyde solution, or ammonium compounds. Construct barriers to prevent spread.
Fusarium wilt	Use wilt-resistant varieties. Fertilize to produce more vigorous plants. Add humus to soil. Rotate to reduce root knot.
Verticillium wilt	Rotate with alfalfa or grain crops.
Root knot	Rotate with immune crops. In irrigated valleys of the Southwestern States maintain clean fallow with deep summer tillage.
Anthracnose	Avoid susceptible varieties. Select seed from disease-free plants or use seed from areas least affected by disease. Rotate crops.
Bacterial blight	Use disease-free seed. Treat seed with organic-mercury dust disinfectants.
Rust	Add humus to the soil. Use potash fertilizers. Drain wet land.
Crazy top	Rotate with alfalfa.

This bulletin is a revision of and supersedes Farmers' Bulletin 1187, Cotton Diseases and Their Control.

Washington, D. C. Issued May 1935

COTTON DISEASES AND METHODS OF CONTROL

By David C. Neal, *senior pathologist, Division of Cotton and Other Fiber Crops and Diseases,* and W. W. Gilbert, *senior pathologist, Division of Fruit and Vegetable Crops and Diseases, Bureau of Plant Industry*

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IMPORTANCE OF COTTON DISEASES

COTTON is the most important crop in the Southern States, and within recent years a considerable expansion of the industry has occurred in the irrigated and semiarid sections of the Southwest. In most of the cotton-growing area of the United States the crop is frequently attacked by plant diseases, some of which cause serious losses.

Estimates of the Plant Disease Survey of the Bureau of Plant Industry indicate a loss to the cotton crop from plant diseases in 1932 of 1,687,000 bales. Several of the cotton-producing States were not considered in these estimates, however, and from observations the writers believe that the loss from this cause actually exceeds 2,000,000 bales annually.

The major diseases of cotton are described and illustrated and the best known methods of control are discussed in this bulletin.

ROOT ROT

Root rot is the most important and the most destructive cotton disease in the United States. It is confined largely to the highly calcareous and alkaline soils of the Southwestern States. The region of greatest damage is in Texas in the heavy, black, waxy soil areas. In that State the disease is known to occur in 196 counties. It also occurs in Oklahoma and Arkansas in a few counties adjacent to Texas, and in some of the irrigated valleys of New Mexico, Arizona, and southern

California. The disease also is reported as causing serious damage to alfalfa in Washington County, Utah. The annual losses from root rot run into millions of dollars, and in Texas alone the annual damage to cotton is estimated to be between 10 and 15 percent of the crop. Including the damage to the many other kinds of plants that are attacked by root rot, it has been estimated that the total annual loss caused by this disease in Texas is about $100,000,000.

The root-rot fungus is apparently native, as it is often found on wild plants remote from cultivation, and it frequently attacks cotton and alfalfa when planted on newly cleared land.

SYMPTOMS

Root rot usually appears in cotton fields about the latter part of June or early in July, though in some localities, as in the Rio Grande Valley of Texas, where the crop is planted as a rule in February, it is not unusual to find well-defined spots of infection during May. The first symptom of the disease is a slight yellowing or bronzing of the foliage, followed by the sudden wilting and death of the plant (fig. 1). Neighboring plants are soon attacked, and this continues throughout the season, the rapidity of spread being somewhat dependent on moisture conditions. During warm periods immediately following rainy weather, outbreaks are especially noticeable, and by late summer or early fall many brown spots or irregular patches of dead plants (fig. 2) may be observed. Root-rot affected areas, particularly in the black-land sections of Texas, assume a reddish-brown to black color because of the dead plants, and present a striking contrast to adjoining green, healthy plants.

CAUSE

The root rot of cotton and many other plants is caused by a fungus (*Phymatotrichum omnivorum*) which lives in the soil and attacks and destroys the roots. Although the fungus is found almost entirely in alkaline as distinguished from acid soils, the actual cause of the disease is not an accumulation of so-called "alkali salts" in the soil, as so many cotton growers believe, but the fungus, which attacks the roots. If the roots of freshly wilted plants are examined, a whitish growth is found on the surface, and frequently wartlike wefts occur at the lenticels (fig. 3). In the case of plants that have been wilted for some time, the growth of the causal fungus on the roots is buff to yellowish brown and shows a development of coarse brown strands (fig. 4).

The points of invasion of the root system by the fungus usually are located on the taproot a few inches below the surface of the ground. The infected areas on the roots are depressed, bronze to dark brown in color, and are separated from the healthy tissue by a reddish-brown border. As growth of the fungus proceeds, the infection spreads and rapidly envelops the greater portion of the root system. On roots infected for some time the bark is so shrunken and soft that it slips easily from the wood. When the roots become seriously injured absorption of water from the soil becomes so diminished that the plant cannot replace that lost by transpiration from the leaves, and it wilts. It is not unusual, however, to find the

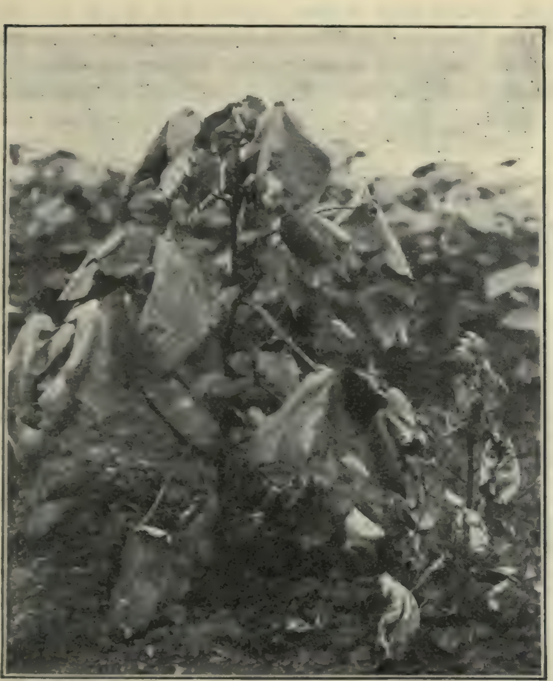

FIGURE 1.—A cotton plant infected with root rot, showing the characteristic sudden wilting.

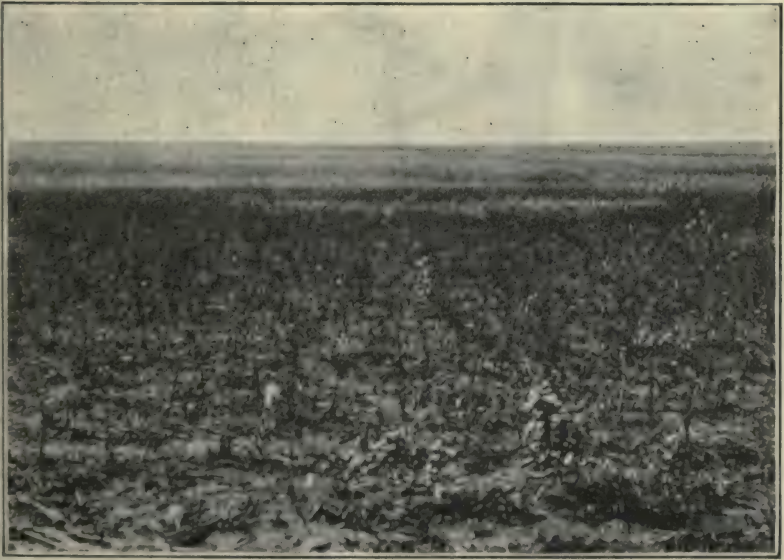

FIGURE 2.—Appearance of root-rot spots in a cotton field late in the season, showing irregular patches of blackened and dead plants surrounded by living green ones.

taproot almost completely rotted away, yet with no aboveground symptoms of the disease. In such cases the plants sometimes remain alive for several weeks, or through the entire season, supported by one or two shallow lateral roots which have escaped infection.

PERSISTENCE AND SPREAD

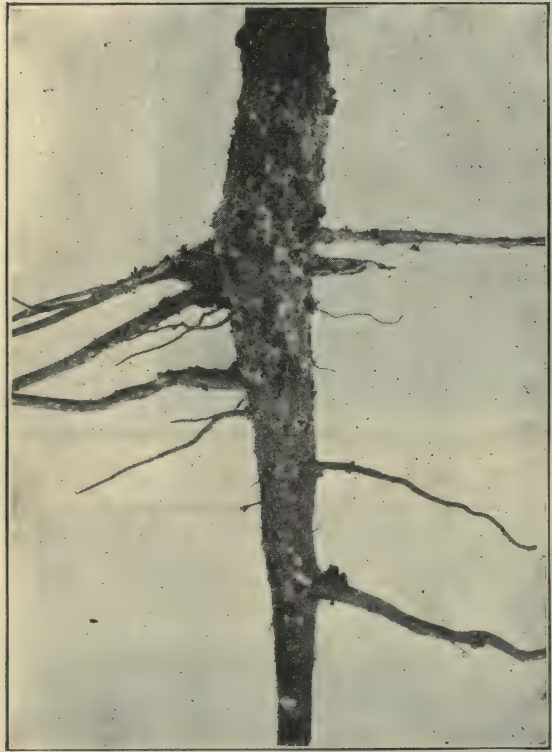

FIGURE 3.—Appearance of roots of a cotton plant infected with root rot. Note wartlike wefts of the fungus at the lenticels.

The fungus may live over from one season to another on the roots of infected plants. Recent experiments have shown also that the root-rot fungus has a sclerotium or hold-over stage which constitutes one of the principal means of carrying over the disease organism in the soil. By means of these sclerotia the fungus is able to remain alive for long periods, at least 3 or 4 years, even in the absence of cotton or other susceptible plants. Numerous excavations made in infested plots kept in clean fallow for 3 and 4 years and in others following 2 and 3 years of grain (resistant crops) have yielded viable sclerotia and strands of the fungus which may produce infection. The sclerotia or hold-over bodies vary considerably in size and shape, but usually are round to ovoid, flattened, and range from the size of a mustard seed to that of a kernel of wheat (fig. 5). These structures are white when newly formed but with age turn yellow to reddish brown. They have been found in the soil beneath infected cotton plants at depths ranging from 2 to 30 inches and frequently occur in colonies or "pockets" in chainlike arrangement (fig. 6), especially in the heavy black lands of Texas. Deep-seated infestation in many sections of Texas and Arizona is also common, both sclerotia and coarse strands of the fungus often existing on roots and stumps of trees killed by the disease several years before.

During favorable seasons, especially in warm periods following rainy weather, the root-rot fungus may spread rapidly in the field, the infested areas in cotton or alfalfa fields usually enlarging from a center in ever-widening circles. The spots where all the cotton plants have died in one season may break up or disappear in following seasons and later recur independent of any cultural treatment.

Little is known regarding the means of dissemination of the fungus to new locations. Since, however, sclerotia and strands of the fungus as well as infected plant roots may perpetuate the disease, any practice involving soil transfers from infested localities should be carefully avoided, so as not to risk the introduction of the disease into root-rot-free areas. The movement of balled nursery stock or ornamental plants from root-rot areas is restricted in some States by quarantine regulations.

OTHER PLANTS AFFECTED

In addition to cotton, more than 600 cultivated and wild plant species are known to be susceptible to root rot. Important cultivated crops attacked by the disease include alfalfa, clovers, peas, beans, peanuts, sweetpotatoes, turnips, carrots, and okra. Many fruit trees, ornamental plants, and shade trees are also affected. Among the trees and shrubs frequently killed by root rot are apples, figs, grapes, plums, elms, chinaberry, mulberry, poplar, sycamore, rosebushes, and privets. Some trees, such as citrus, pecan, hickory, cottonwood, pomegranate, and athel (*Tamarix aphylla*), if not killed in the seedling stage are able to withstand the disease and may live for many years.

CONTROL

ROTATION AND CULTIVATION

Owing to the great diversity and number of plants affected by root rot and the fact that the organism persists in the form of sclerotia and strands, no very satisfactory control measures have as yet been developed. In Texas, where the disease is particularly serious, a 2-year or preferably a 3-year rotation with grain crops, combined with deep tillage immediately after the grain is harvested, has reduced the disease somewhat. Rotation may include corn, wheat, oats, and especially grain sorghums, or other crops that have been found resistant to root rot. As a cultural treatment, liberal

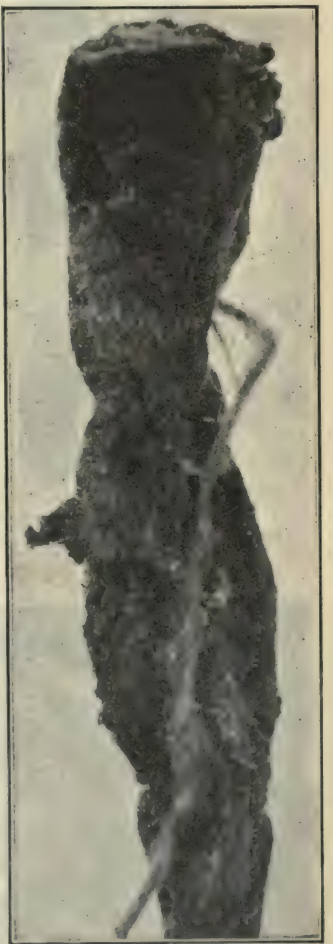

FIGURE 4.—A cotton root showing the well developed coarse brown strand growth of the root-rot fungus. × 11.

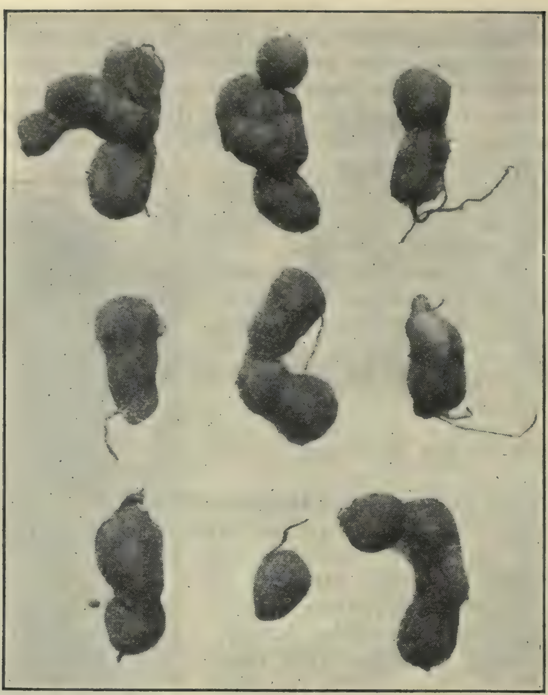

FIGURE 5.—Sclerotia or hold-over bodies of the cotton root-rot fungus. × 6½.

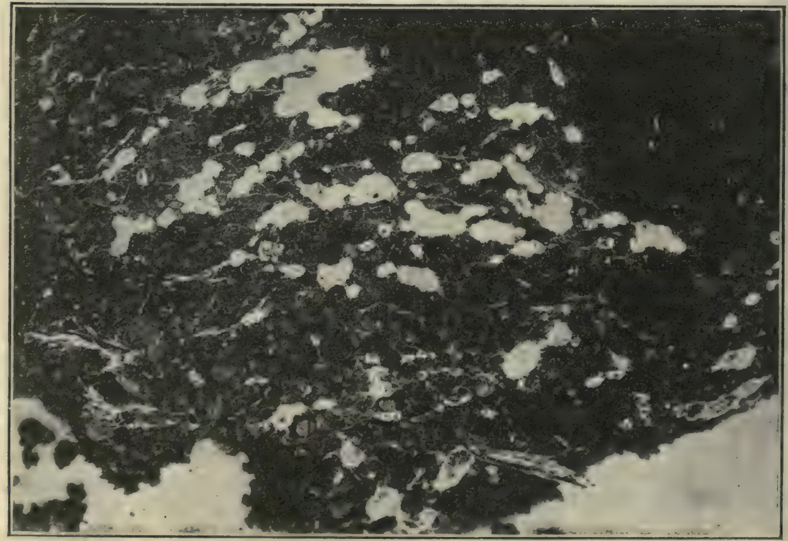

FIGURE 6.—A lump of soil broken open, showing the chainlike arrangement of the sclerotia of the root-rot fungus as they occur in Texas black-land soils. (Nearly natural size.)

applications of organic manures have been effective in some irrigated regions.[1]

The more important plants grown in the area where root rot prevails and their resistance or susceptibility to the disease as determined in tests by the Texas Agricultural Experiment Station are as follows:

Crops highly resistant to root rot

Asparagus
Barley
Corn
Grasses
Millet
Oats
Onion
Rice
Sorghum
Strawberry
Sugarcane
Wheat

Crops partially resistant to root rot

Cabbage
Cauliflower
Collards
Cucumber
Guar[2]
Kale
Lettuce
Muskmelon
Pea, garden
Peach
Pecan
Potato
Tobacco
Tomato
Turnip
Velvetbean

Crops most susceptible to root rot

Alfalfa
Apple
Bean
Clover
Cotton
Cowpea
Fig
Grape
Peanut
Pear
Privet
Rose
Soybean
Most vegetables

Weeds attacked by root rot

Cocklebur
Groundcherry
Horsenettle
Lambsquarters
Ragweed
Tievine

SOIL DISINFECTION

Although many soil disinfectants have been tried in attempts to eradicate root rot, the results in general have not been satisfactory. However, for eradicating small centers of infection in cotton fields or in areas where one desires to make limited plantings of fruit trees, shade trees, or ornamental plants, dilute solutions (2 and 4 percent, respectively) of either formaldehyde or ammonia water[3] may afford protection. Ammonium phosphate or ammonium sulphate plus hydrated lime (3 parts of lime to 5 parts of ammonium sulphate) may also be used in treating small areas of infection, if the work is thoroughly done.

The formaldehyde solution is made by placing 2½ gallons of formaldehyde (40-percent U. S. P.) in a barrel or other wooden container and diluting with water to make 50 gallons. Approximately 4-percent ammonia water is prepared by adding 8 gallons of strong ammonia water (28 percent) to 42 gallons of water. The soil in the diseased area should first be thoroughly worked or spaded to a depth of 12 to 18 inches and then saturated with the ammonia solution at least 6 to 8 months before planting.

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[1] Demonstrated to be a practicable control measure in Arizona.

[2] An East-Indian annual legume introduced into the arid parts of the United States as a forage crop.

[3] Preferable for Texas black-land soils.

It should be remembered, however, that the effective use of soil disinfectants is restricted to areas where the fungus can be reached by such treatment. In many of the infested districts of Arizona, southern California, and southern Texas the fungus often extends to depths of 4 or 5 feet, and in such cases the use of disinfectants for eradication purposes becomes impracticable.

BARRIERS

Various kinds of barriers to limit the spread of root rot in the field have been developed. Among these are trench barriers containing mixtures of soil and such chemicals as ammonia and sulphur; mixtures of soil and waste motor oil, and open trench barriers of varying depths. One with ammonia may be prepared by digging a trench 10 to 12 inches wide and 1 foot deep, about 4 to 6 feet in front of the zone of infected plants, and saturating this with 6-percent ammonia water [4] at the rate of 1 gallon per lienar foot. The trench is then filled with soil from a root-rot-free area. A similar barrier may be made with waste motor oil. When waste motor oil is used, however, a trench 6 inches wide and about 20 inches deep is advisable, and dry soil is necessary for thorough incorporation of the oil. The two are mixed in the proportion of 1 part of oil to 10 parts of soil by weight. After the trench has been dug to the stated depth the desired barrier width is obtained by using board forms in the trench and filling the space with the oil-soil mixture. The latter is packed down thoroughly and the forms removed after the space on the opposite side has been filled with soil.

The Texas station also has found that 4 to 12 rows of grain sorghum are valuable barriers to prevent the spread of root rot.

FUSARIUM WILT

Fusarium wilt, commonly called black root, from the fact that the diseased roots turn black, and known also as cotton wilt, is a disease occurring in many sections of the Cotton Belt. It is second only to root rot in the amount of loss it causes to the crop. It is especially prevalent on the light sandy soils of the Coastal Plain, extending from Virginia to New Mexico. It is less prevalent on clay or alluvial soils, but it does occur in such areas. It is most common and severe in eastern North Carolina, central and eastern South Carolina, central and southern Georgia and Alabama, Mississippi, Louisiana, eastern Arkansas, Oklahoma, and Texas. Recent surveys show that cotton wilt is on the increase in both the sandy and the heavier upland soils of South Carolina and Mississippi. In most of the States mentioned above it is the most important and destructive cotton disease. It occurs every year, though in some seasons losses are heavier than in others. In occasional severe cases the yield is sometimes reduced as much as 75 to 90 percent. Instances of damage amounting to 25 percent or more are not uncommon wherever the disease is present in the soil to any appreciable extent and nonresistant varieties are grown. The average annual loss due to wilt is estimated to be about 4 or 5 percent.

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[4] Approximately 6-percent ammonia water in 50-gallon lots is prepared by adding 11½ gallons of strong ammonia (28 percent to 38 gallons of water.

SYMPTOMS

Fusarium wilt of cotton usually makes its appearance about the last of June or early July, but occasionally the plants are attacked and killed even in the seedling stage. This disease may be suspected when plants wilt and die without any apparent reason. Early in the season wilt-infected plants appear dwarfed as compared with healthy plants, and the leaves turn yellow at their margins and between the veins. Frequently the main stem of infected plants remains short, while one or more lower branches grow normally (fig. 7). The chief symptoms are premature wilting and the characteristic internal appearance of affected stalks. If the stem of a freshly wilted plant is cut across near the ground and the vascular tissues are brown or black inside, there is strong evidence of the disease. This vascular discoloration may extend up the stalk into the main branches, frequently into the leaf petioles and pedicels, and sometimes into the seeds (fig. 8). Other symptoms of wilt are shorter taproots, fewer lateral roots, and the excessive shedding of leaves, producing bare stalks. Also, in many cases, the upper part of the plant dies.

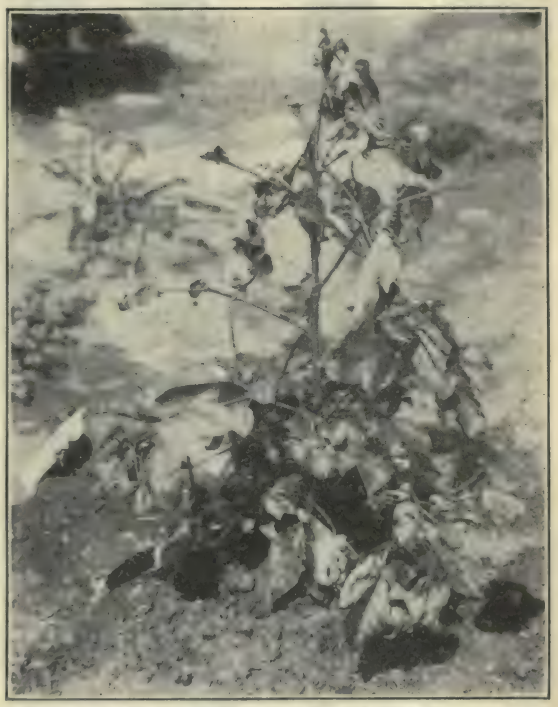

FIGURE 7.—Cotton plant infected with fusarium wilt. Note stunted appearance and partial defoliation.

CAUSE AND SPREAD

Cotton wilt is caused by a fungus (*Fusarium vasinfectum*), which lives in the soil and infects the plant through the roots. By its growth it produces toxic substances which finally accumulate in sufficient quantity in the plant to cause wilting and death. The wilt fungus is able to live in the soil for several years, so that crop rotation as a control measure is not effective. After the plants are killed the fungus continues to grow within the tissues, eventually rotting the roots, and later, if conditions are favorable, it forms spores (reproductive bodies) in abundance on the roots and infected stems which are left in the soil.

It is generally believed that cotton wilt, like many other wilt diseases of various crops, may be spread from field to field by animals, men, cultivating implements, wind, drainage water, or other agencies that carry soil particles. Experiments have shown, however, that the disease is not easily conveyed from one field to another by such means. There is also very little evidence that the disease is disseminated in practice to any appreciable extent in or on the seed, although in a few cases this has been done experimentally.

CONTROL

The planting of wilt-resistant varieties of cotton and liberal fertilization to produce more vigorous plants are the most effective methods of controlling wilt. Large applications of potash alone and fairly large applications of potash in combination with nitrogen- and phosphorus - containing salts, according to the Arkansas Agricultural Experiment Station, have reduced cotton wilt at points in central, eastern, and northeastern Arkansas. The Mississippi Agricultural Experiment Station also reports that fertilizers high in nitrates and potassium have uniformly given a smaller amount of infection on inoculated soil. Experiments in both of these States have shown that the amount of wilt and rust is greatly reduced through applications of 600 pounds per acre of 6–8–12 or 6–8–6 (N–P–K)[5] fertilizer. The control of wilt through such fertilizer applications also is usually accompanied by marked increases in yield. Measures that maintain an adequate content of organic matter in the soil and crop rotation are important supplemental factors in decreasing wilt damage. The use of vetch, winter peas, crimson clover, root-knot-resistant varieties of cowpeas, and soybeans as soil-building crops increases production, aids in delaying infection by the wilt fungus, and assists in maintaining the resistance of the cotton plant to wilt and other diseases.

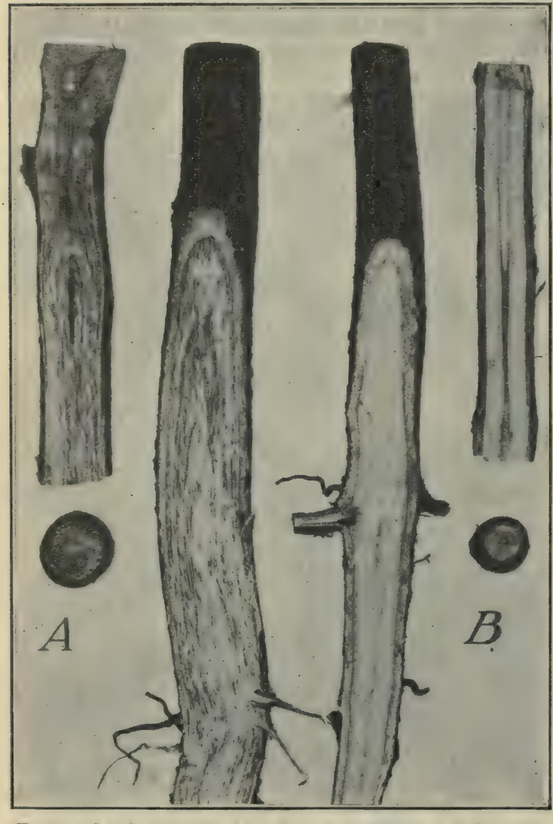

FIGURE 8.—Longitudinal and cross sections of fusarium wilt-infected and healthy cotton stems and roots: *A*, Wilt-infected; *B*, healthy. Note black discoloration of diseased tissues as shown in *A*.

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[5] Nitrogen phosphorus potash.

In areas where root knot is prevalent, especially in light sandy soils, wilt is also more prevalent and destructive. In these localities it is necessary to plant root-knot-resistant crops for 1 or more years before attempting to control the wilt even by growing wilt-resistant varieties of cotton.

WILT-RESISTANT VARIETIES

Several wilt-resistant varieties of cotton have been bred by the United States Department of Agriculture, by various State experiment stations, and by a number of cotton breeders. Some of these varieties are planted extensively, and for many years have produced profitable crops on wilt-infested soils. Wilt-susceptible varieties cannot be used successfully on land that is heavily infested with the wilt fungus (fig. 9).

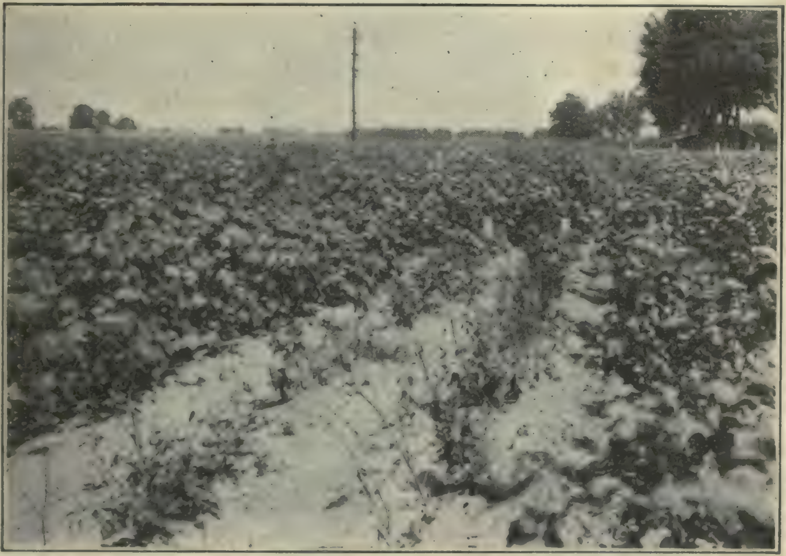

FIGURE 9.—Resistant and susceptible varieties of cotton growing on wilt-infested soil. Note the vigorous growth and healthy appearance of the resistant varieties at the right and left as compared with the scant growth and sickly appearance of the two susceptible varieties in the center.

Among the wilt-resistant, short-staple upland varieties developed by the Department and selected for earliness, productivity, and qual- more productive, matures earlier, and has a better staple, ranging ity of fiber are Dixie and Dixie Triumph. Of these, the latter is from fifteen-sixteenths of an inch in some localities to $1\frac{1}{32}$ inches in others. It is planted extensively in the wilt-infested districts of North Carolina, South Carolina, and Georgia and in parts of Alabama, Louisiana, and Arkansas. A number of other wilt-resistant cottons have been developed in recent years. Among these are Tri-Cook, Cook 307–6, Cleveland 54, Miller 642, Express 121, Dixie 14, Rowden 40, D & P L 6, D & P L 4–8, Coker Lightning Express, Coker Super Seven Strain 5, Clevewilt, Rhyne Cook, Covington-Toole, Council Toole, Lewis 63, and Watson Long Staple. Other resistant strains, some of which have considerable merit for local conditions, have been developed by individual farmers in various States. Further information concerning these may be obtained from the State experiment stations in the Cotton Belt or from the United States Department of Agriculture.

The breeding of wilt-resistant strains of cotton is a long and tedious operation, requiring in most instances special facilities in the way of uniformly infested land, isolation of seed plots, and special ginning. Because of the expense, it will not pay the average farmer to produce his own wilt-resistant strains. If his land is infested, new seed of a wilt-resistant variety adapted to his locality should be obtained every 2 or 3 years, either from his State experiment station, from a reliable breeder, or from some carefully managed one-variety cotton community.

VERTICILLIUM WILT

Verticillium wilt of cotton, similar in many respects to fusarium wilt, has been known in the United States only since 1927. It is known to occur in Arkansas, California, Mississippi, Oklahoma, Tennessee, and Virginia. The disease is quite prevalent in the Delta counties of Mississippi, in Tennessee and Arkansas, and in the San Joaquin Valley of California. In the Mississippi Delta the infection varies from a trace to as much as 40 percent in some fields.

SYMPTOMS

In the Delta sections of Mississippi and in Tennessee the disease appears about the first week in July, usually following rainy weather, as the plants are approaching maturity. The symptoms of the disease as found in this region agree very closely with descriptions given of this wilt in California.

The first outward symptom is a distinct mottling of the leaves with pale-yellowish irregular areas appearing at the margins and between the principal veins, showing a deficiency of chlorophyll. These symptoms occur in early summer, usually on the lower leaves of the plant, spreading to the middle and upper leaves later in the season. The yellow areas gradually become paler, finally dying and turning brown (fig. 10). At the time or even before the yellow discoloration appears in the leaves, a longitudinal cut into the wood at the base of the main stalk may reveal a slight browning of the vascular system, which later becomes very pronounced. In the late summer, when the effect of the disease is most apparent, the leaves of badly diseased plants present a mosaic pattern of rust-colored dead areas with yellowish margins, lying between narrow strips of green, bordering the principal veins. Later the leaves fall, and the plant may become defoliated except for a few small leaves at the top of the plant and at the ends of the branches.

The leaf symptoms mentioned above, such as mottling and discoloration, although characteristic of this disease, also occur in cotton plants infected with fusarium wilt and hence cannot be used as a distinguishing character for either disease. Discoloration of the vascular tissues of the stems and roots also occurs in both wilts. Although difficult to distinguish from fusarium wilt except by laboratory culture methods, some differences in the two diseases may be recognized. Plants infected with fusarium wilt are characterized by dwarfing and are frequently killed during the season, whereas those infected with verticillium wilt are not dwarfed, seldom are killed, and often produce yields comparing favorably with normal plants. The development of new slender branches at the base of the plant (fig. 11) also frequently occurs in cotton plants infected with *Verticillium*. The almost complete shedding of leaves during August and September is especially characteristic of cotton plants infected with verticillium wilt (fig. 12), the same symptoms occurring much earlier and to a somewhat less extent in plants infected with fusarium wilt.

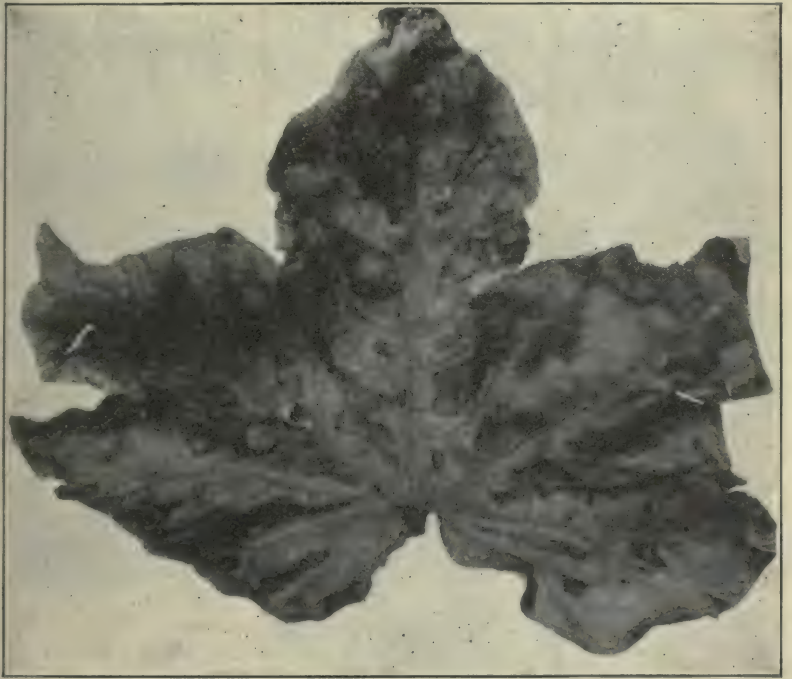

FIGURE 10.—Leaf from cotton plant infected with verticillium wilt. The dead areas are brown, with pale-yellowish margins.

CAUSE

Verticillium wilt is caused by a soil fungus (*Verticillium alboatrum*) which enters the roots of the cotton plant in the same manner as described for fusarium wilt. It causes wilting, mottling, and shedding of leaves and vascular discoloration of the roots and stems.

The disease attacks many other plants besides cotton, such as potatoes, tomatoes, and deciduous fruit crops. It may have been introduced into certain cotton-growing localities through the planting of some of these crops, especially infected potatoes, which are grown extensively in areas where the disease has been known to occur for several years. The appearance of the disease in cotton communities in which other susceptible crops have not been grown previously to any considerable extent would indicate, however, that there are other sources of infection. Perhaps the fungus may be transferred by flood waters from *Verticillium*-infested districts or by other agencies that carry infested soil.

There is as yet no evidence that the disease is disseminated in the seed. Seed collected from infected plants in the Mississippi Delta and in California in 1929 and planted on disease-free soil the following season produced healthy plants.

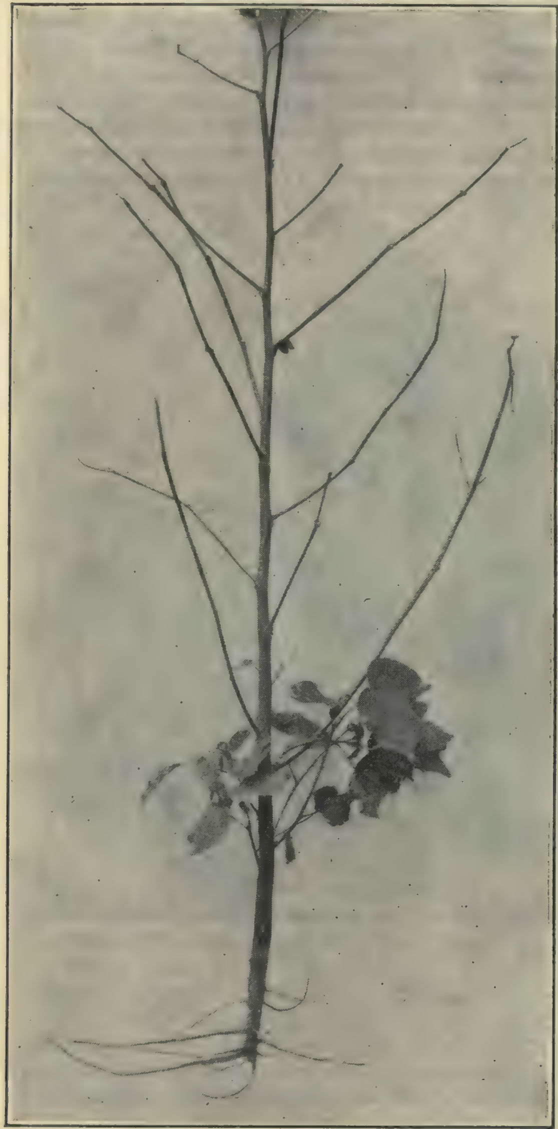

FIGURE 11.—A cotton plant infected with verticillium wilt, showing the development of new slender branches at the base of the stalk. This is a distinctive feature of the disease in the Mississippi Valley.

CONTROL

No definite control measures for verticillium wilt are known. Rotation with alfalfa or grain crops is suggested as a possible means of reducing infection in cotton fields. Breeding resistant varieties of cotton may solve the problem.

ROOT KNOT

Root knot affects the cotton crop more or less in practically every State in the Cotton Belt. Like wilt, it is most severe on sandy soils of poor water-holding capacity. The disease is widely prevalent in the Coastal Plain and the sand-hill and light-soil areas of Florida, Georgia, Alabama, North Carolina, South Carolina, Mississippi, Louisiana, Arkansas, and Texas. It occurs also in southern California and in Arizona. The

Plant Disease Survey of the Bureau of Plant Industry estimates a loss to the cotton crop from root knot varying from a trace to as much as 4 percent annually in some States. Losses in exceptional cases may amount to 80 percent. The average losses for all sandy lands in a single county in South Carolina were estimated at 4.4 percent in 1917, and in 1932 the loss for the State of North Carolina was estimated at 5 percent.

Every cotton farmer should realize that the damage caused by root knot is not confined to direct injury to the cotton plant. Root-knot-diseased plants are also much more subject to wilt, and the two diseases occur very commonly together. For this reason cotton wilt is much worse following root-knot-susceptible cowpeas or other crops that increase the causal agent in the soil. Loss from root knot also is increased (1) by the greater cost of cultivating infested land due to weed growth where the cotton has died, (2) by lowering the market value of such land, and (3) by the fact that badly diseased land must often be used for crops less profitable than cotton. Many other farm crops are also susceptible to this trouble.

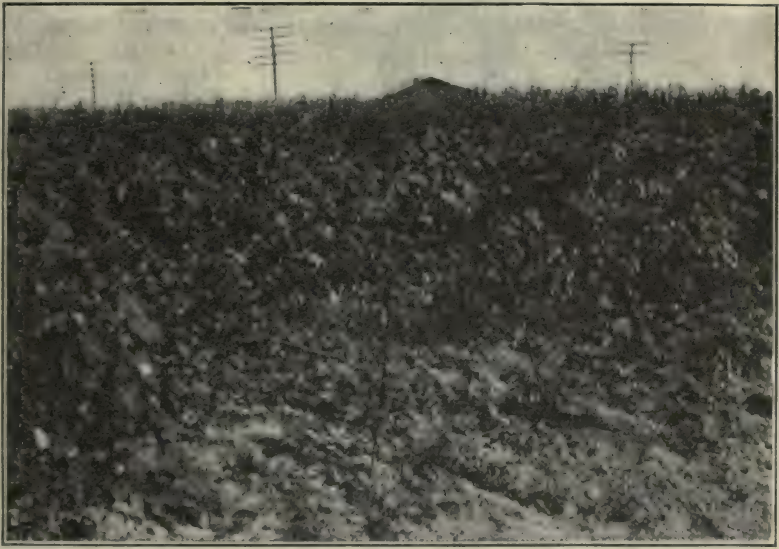

FIGURE 12.—Cotton plants growing in Washington County, Miss., showing almost complete defoliation as a result of verticillium wilt infection. (Photographed in October.)

SYMPTOMS

Plants affected with root knot are usually dwarfed or stunted, and the leaves and stems are pale yellowish green. Deformities, such as irregular branching and the dying back of the main stalk, which characterize plants infected with fusarium wilt (fig. 7) are not usual in plants affected with root knot. In mild cases of the disease even the dwarfing and abnormal color of the leaves may not be especially noticeable. Severe attacks, however, may kill practically all the plants in the field. During hot, dry weather affected plants tend to wilt more than normal ones. The pest affects all susceptible crops alike, causing swellings, galls, and discolorations of the roots, which stunt the growth of the plants by cutting off the food and water supply. The disease can be identified by examining the affected roots. If they show numerous more or less irregular knots or swellings, ranging from the size of a pinhead to one-half inch or more in diameter (fig. 13), root knot may be suspected. The knots or galls occur on both the feeding rootlets and the taproot, depending on the severity of the attack. When young, they are white; but with age they turn brown and decay. Root knot is especially severe on Egyptian cotton when planted on areas infested with the causal agent. In Arizona seedling stands frequently are greatly reduced by root-knot injuries, which growers usually attribute to sore shin.

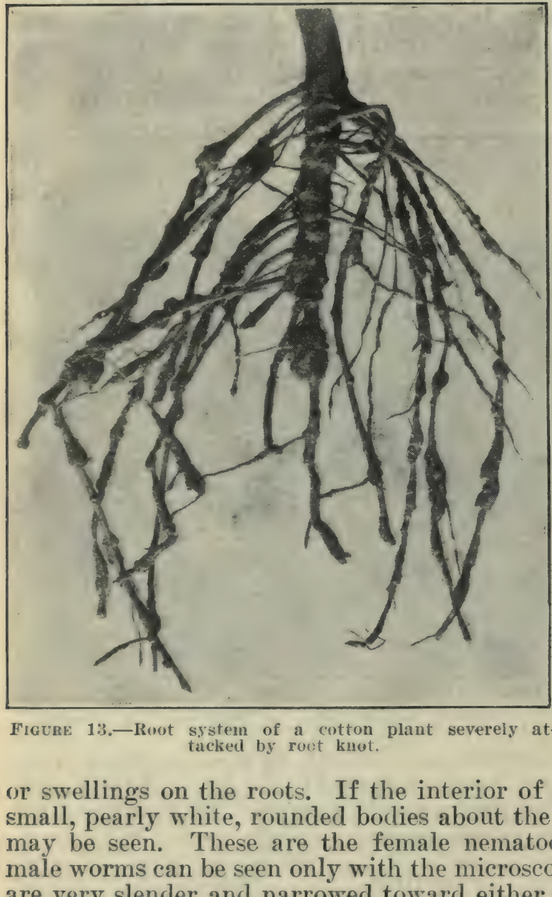

FIGURE 13.—Root system of a cotton plant severely attacked by root knot.

CAUSE AND SPREAD

Root knot of cotton and other crops is caused by minute eelworms or nematodes (*Heterodera marioni* (*Caconema radicicola*)) which bore into the roots from the soil. They multiply inside the root tissue, living at the expense of the plants and causing them to form galls or swellings on the roots. If the interior of the knots is examined, small, pearly white, rounded bodies about the size of a mustard seed may be seen. These are the female nematodes (fig. 14, *A*). The male worms can be seen only with the microscope or hand lens. They are very slender and narrowed toward either extremity (fig. 14, *B*).

The root-knot organism may spread from field to field in various ways. It may be transmitted by drainage water, irrigation water, agricultural implements, cultivation, soil clinging to the feet of animals or men, or by any means that carry infested soil or plant roots. The introduction of the disease into new localities is often accomplished by means of infested nursery stock, tubers, bulbs, and seedlings. Young peach trees, figs, grapevines, cabbage, tomato, and strawberry plants, or other plants grown in infested soil, as well as infested potatoes and sweetpotatoes used for seed purposes, are frequently responsible for the dissemination of root knot.

CONTROL [a]

Rotation with nonsusceptible crops, so as to starve out the nematodes in infested fields, is the most effective and practicable means of controlling root knot. In fields where the disease is severe, winter grains, resistant summer legumes, or other resistant crops should be grown for at least 2 or 3 years in succession before the land is returned to cotton. Such a rotation consistently followed gives fair control, whereas the continuous planting of cotton on infested land or following other susceptible crops will almost invariably result in heavy losses. In the irrigated valleys of the Southwestern States root knot of field crops can be eradicated by clean fallow with deep summer tillage in about 3 years.

A list of cultivated plants, including both field and truck crops, which are resistant or susceptible to root knot is given below. From these, suitable rotations may be devised for most localities.

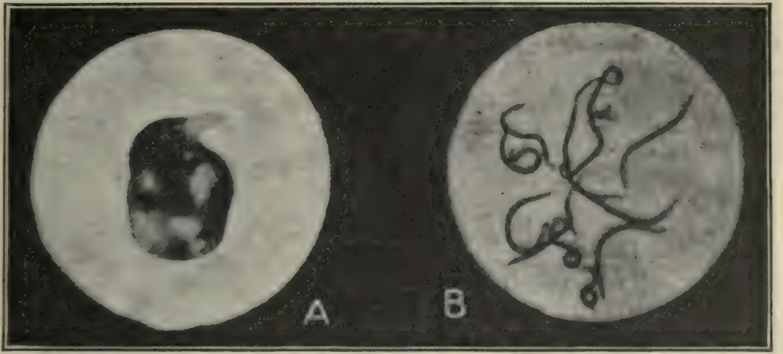

FIGURE 14.—The nematodes that cause root knot: *A*, Adult female full of eggs (× about 24); *B*, larval specimens (× about 60).

Crops largely or entirely immune to root knot

Barley
Beggarweed, Florida
Chufa
Corn
Cowpea (Brabham, Iron, Victor)
Crotalaria spectabilis
Grasses (nearly all, including Bermuda grass and crabgrass)
Kafir
Millets (nearly all)
Milo
Oats, winter
Peanut
Rye
Sorghum
Soybean (Laredo variety only)
Velvetbean
Wheat

Crops not very severely affected by root knot

Alfalfa
Asparagus
Bean, snap
Cabbage
Collards
Cotton
Pea, garden
Radish
Soybean (Otootan)
Spinach
Strawberry
Sugarcane
Sweetclover
Sweetpotato
Vetch, common

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[a] More detailed information on root knot and its control is given in Farmers' Bulletin 1345, Root Knot, Its Cause and Control. This publication may be purchased for 5 cents from the Superintendent of Documents, Government Printing Office, Washington, D. C.

Crops most severely affected by root knot

Bean, lima
Beet
Bur-clover
Carrot
Celery
Cowpea (all varieties except Iron, Brabham, and Victor)
Cucumber
Eggplant
Fig
Lettuce
Muskmelon
Okra
Peach
Potato
Salsify
Soybean (all varieties except Laredo and Otootan)
Squash
Tobacco
Tomato
Watermelon
Papaya

Weeds susceptible to root knot

Balloonvine
Clover, Mexican
Fennel, sweet
Maypop, or passionflower
Mayweed
Purslane

ANTHRACNOSE

Anthracnose, or pink boll rot, occurs in many of the cotton States. It is common in the mid-South, in the Southeastern States, and in many localities where cotton grows rank or where rainfall occurs at frequent intervals during the growing season. In some localities only a fraction of 1 percent of the crop is lost from this disease, while in others the losses may range from 40 to 60 percent.

SYMPTOMS

As the common name implies, anthracnose is primarily a disease of the bolls, but it may attack the leaves, stems, and bracts. It is also frequently responsible for poor stands, resulting from seedling infection and damping-off during cool, wet weather soon after planting. On the bolls the disease first appears as small, round, water-soaked spots, which later enlarge, become sunken, and finally develop reddish borders and characteristic pink centers (fig. 15). The pink centers of the spots are due to the spores of the fungus, which develop in abundance during periods of moist, cloudy weather. At other times the spores are scarce, and the diseased areas may have a grayish cast. The lint from infected bolls is often stained pink, is inferior in quality, and in many instances may be entirely rotted and worthless.

CAUSE

Cotton anthracnose is caused by a fungus (*Glomerella gossypii*) which lives over the winter on diseased bolls and stalks left in the field. It also overwinters in and on the seed from infected plants, and the planting of infected seed constitutes one of the principal means of spreading the disease.

CONTROL

Effective control of anthracnose is accomplished by selecting seed from disease-free plants, by using seed from areas with a minimum of infection, by using 3-year-old seed from slightly diseased fields, and by avoiding varieties that are known to be susceptible. The Half and Half and most Cook cottons are susceptible varieties.

Rotation of crops is also an important supplemental control measure. Since it has been shown that the fungus dies out in the seed after 12 to 14 months, the use of 2- and 3-year-old seed is a practical control measure, provided the land is free from infestation. With the necessary storage facilities to keep the seed dry and to avoid exposure to extremely low temperatures, the germination of 2- and 3-year-old cottonseed is not appreciably reduced.

BACTERIAL BLIGHT

Bacterial blight is variously called bacterial boll rot, angular leaf spot, vein blight, and black arm, depending upon the part of the plant attacked. It occurs generally throughout the South, and also in the southwestern cotton areas, especially in Arizona. This disease can be found every year in almost every cotton field, with damage ranging from a trace to as much as 40 to 60 percent. It is estimated that it causes an annual reduction in yield of upland cotton in the United States of 1 to 2 percent, and from 5 to 15 percent in severe outbreaks in Egyptian and sea island varieties. The latter are much more susceptible, and the damage is greater, owing to the more complete destruction of the bolls and branches. Defoliation, death of seedlings, and shedding and rotting of bolls are the destructive effects of bacterial blight in upland cotton. Damage is especially severe during cold, wet weather, the disease being spread chiefly by wind-blown rain. Dry, hot weather checks the infection, and in many localities cotton planted after the middle of May is seldom affected to any appreciable extent in the seedling stage.

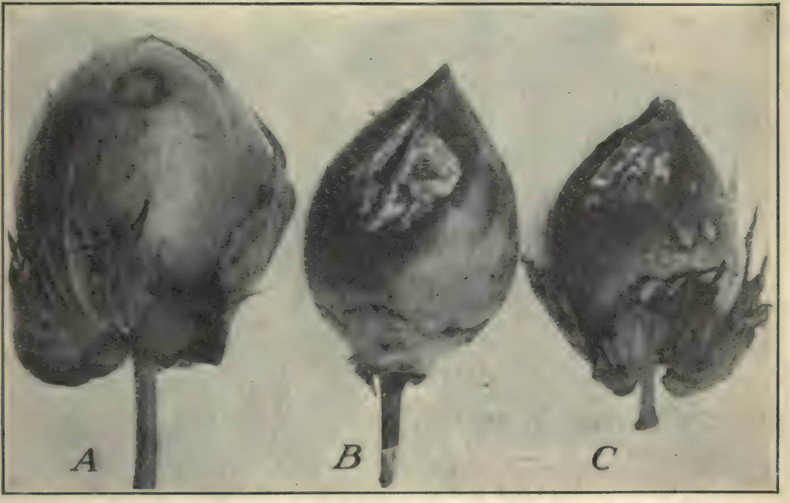

FIGURE 15.—Cotton bolls showing anthracnose or pink boll rot: *A*, Early stage: small water-soaked spot with pink center just appearing; *B* and *C*, bolls showing advanced stages with pink centers well developed.

SYMPTOMS

The first evidence of the disease is seen on the under surface of the cotyledons, young leaves, and stems, where round, green, water-soaked spots of varying size, usually from one-eighth to one-fourth inch in diameter, occur within a week or 10 days after the seeds are planted. If the young leaves are held toward the light the spots appear translucent. Later the infection penetrates to the upper side of the leaves, forming elongated, angular, irregular areas between the veins. The infected areas of the leaves finally become dry and sunken and turn dark reddish brown to black, with the margins of the spots appearing rusty red to purplish (fig. 16). Frequently the disease extends along the veins of the leaf, producing a characteristic phase of the disease commonly called vein blight (fig. 17). This type of blight, although occurring in upland cotton, is more prevalent in sea island and Egyptian varieties, and in severe attacks it causes many of the leaves to turn yellow, curl up, and fall off.

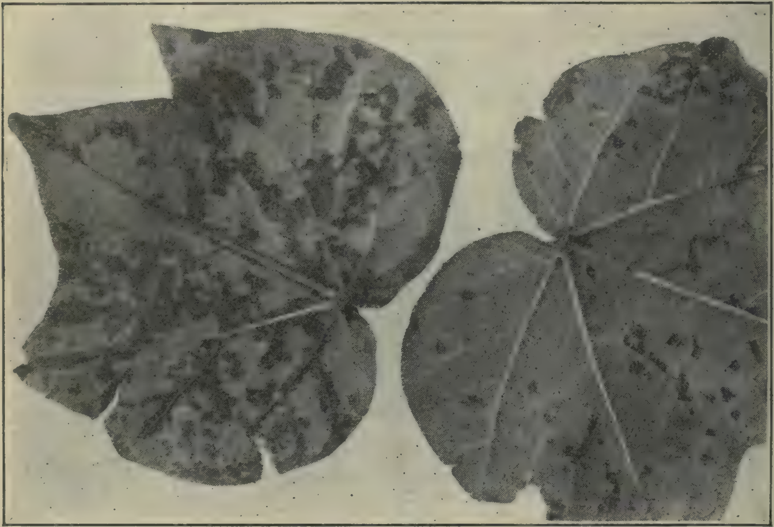

FIGURE 16.—Typical appearance of bacterial blight or angular leaf spot on upland cotton leaves. Note the water-soaked appearance and the distribution of the spots between and along the veins.

On the stems and branches the disease is commonly known as black arm, so called because the outer bark of the branches is killed and later turns black. This phase, although largely restricted to Egyptian and sea island cottons, is also frequently responsible for seedling injury and the death of young plants of upland cotton, especially in the black-land cotton sections of Texas, Arkansas, and Oklahoma. In these sections main stalks and branches of young plants often become infected and killed back for 3 or 4 inches (fig. 18), and the growth of the plants is thus retarded. A serious effect of the disease is that the tops and main stems of black arm-infected plants are easily broken by the wind. In many instances the infection may become so severe that the young plants are completely killed, and the resulting loss in such stands is so great that it is necessary to replant.

The disease is also frequently observed on the cotton flowers, especially following periods of rainy weather accompanied by windstorms and where insect visitation is in evidence. Under these conditions the disease may infect the petals, producing water-soaked, slimy areas usually extending to the base of the flower and infecting the young boll through the calyx, causing it to shed 2 or 3 days after the flower is dropped (fig. 19). The shedding of young bolls as a result of flower infection is one of the most serious aspects of blight and causes heavy losses in some localities. The disease also attacks mature or partially mature bolls. The first signs of the disease on the boll are small, water-soaked, dark-green, slightly raised, roundish spots, which gradually enlarge, turn black, and then shrink, as the tissues are killed (fig. 20). No grayish cast or pink color accompanies the spots caused by blight, as is the case with the anthracnose disease except when there is a subsequent infection with the anthracnose fungus. When bolls are attacked, several locks of the entire boll may be so injured that they fail to open. If the infected bolls do open, the lint is stained brown to black and is of a low grade.

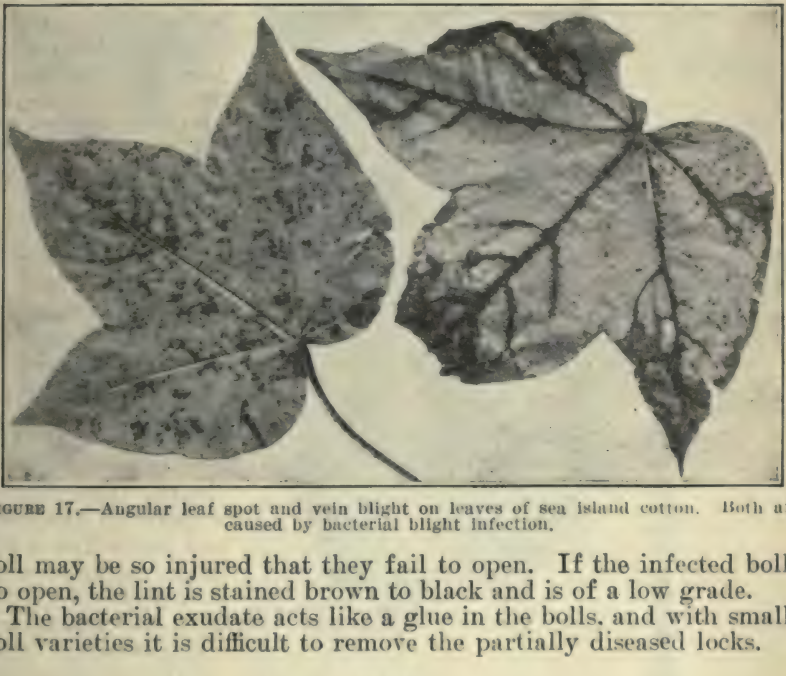

FIGURE 17.—Angular leaf spot and vein blight on leaves of sea island cotton. Both are caused by bacterial blight infection.

The bacterial exudate acts like a glue in the bolls, and with small-boll varieties it is difficult to remove the partially diseased locks.

CAUSE

Bacterial blight is caused by a bacterium or germ (*Bacterium* (*Phytomonas*) *malvacearum*) which enters the leaves, stems, and bolls through the breathing pores and kills the adjoining cells, producing spots on the leaves, dead areas on the branches, and a decay of the bolls. Rainy weather accompanied by wind is an important factor in spreading the bacteria.

The bacteria causing the disease live over the winter chiefly on the seed and possibly on diseased portions of cotton stalks and bolls left in the field from the previous crop. There is very little evidence, however, that the bacteria survive in the soil. They are carried within the seed coat to a certain extent.

CONTROL

The most effective method of controlling blight is to use disease-free seed. The seed may be practically freed of the blight bacteria if treated with special dust disinfectants or if delinted with sulphuric acid or with hydrochloric acid gas.

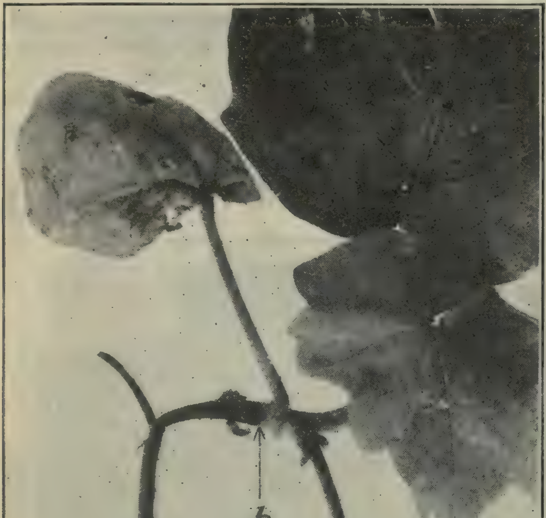

FIGURE 18.—A young cotton plant attacked by black arm (bacterial blight). Note the black diseased area on the stem between *a* and *b*. The infected stems or branches often break during windstorms.

The most effective dust disinfectants are some of the organic mercury compounds. Seed treated with these dusts at the rate of 4 ounces per bushel has given excellent stands of cotton with a minimum of blight-infected seedlings. The dust treatment is simple and inexpensive. The seed to be treated is placed in a closed drum, large cans, or wooden containers with the requisite amount of dust disinfectant and shaken vigorously for 15 to 20 minutes to insure a thorough coating of the dust on the seeds. The seed may then be planted immediately or kept in the containers for any length of time with no danger of injury from the treatment.

Experiments have shown that delinting cottonseed with sulphuric acid is quite effective in eliminating blight bacteria from the seed. Seed so treated, however, may give only fair to poor germination when cool or wet weather follows planting. Especially is this true where the crop is grown under irrigation. The method is also tedious, cumbersome, and dangerous for the grower to use and is not advised as a general farm practice, although it is used by breeders for special lots of seed stocks.[7]

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[7] Persons especially interested may obtain further information on the use of this method by writing to the State experiment stations or to the U. S. Department of Agriculture.

Another method of delinting cottonseed for the control of blight and other diseases, developed in the Bureau of Plant Industry, is the hydrochloric acid gas process.[8]. This method requires special equipment for treating the seed. It has the advantage over the sulphuric-acid method in that the seed is kept dry throughout the treatment. The method is feasible, however, only on a commercial basis.

To be effective, treatment for blight control should include all seed used on the farm. Better still is a community program of seed treatment. If one grower practices seed treatment and the grower on an adjoining plantation does not, the blight bacteria may later be disseminated to the disease-free plants in fields where the seed was treated, produce infection, and reduce the benefits of treatment. A great benefit from seed treatment, however, comes in warding off infection in the seedling stages and insuring more uniform stands and more rapid growth as the season advances.

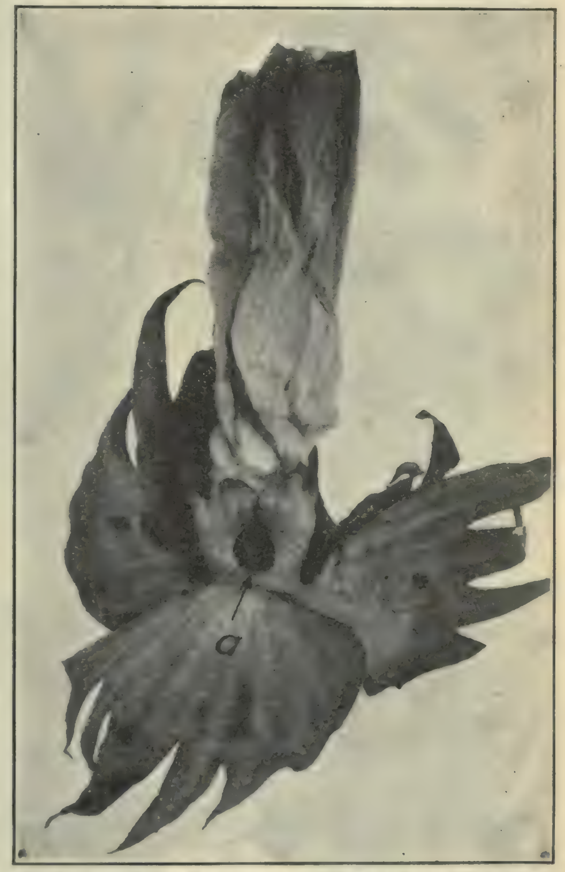

FIGURE 19.—Bacterial-blight infection at the base of a cotton flower (*a*), which later caused the young boll to shed.

RUST

Rust, also called black rust, yellow leaf blight, and potash hunger, is often seen on land of low fertility. This trouble occurs commonly in the Coastal Plain areas of the Cotton Belt, and while usually confined to the lighter soils, it is sometimes observed on the poorly drained, buckshot prairie, limestone sections of several States, especially in Alabama, Arkansas, Louisiana, and Mississippi. The disease varies in severity in different localities and even within the same field, the damage ranging from a trace in some fields to as much as 60 to 75 percent. The average loss for the entire Cotton Belt is estimated to be 4 or 5 percent.

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[8] U. S. patent no. 1425688.

Cotton fields affected by rust usually do not produce plants with normal growth. The plants are small and lack a healthy green color. About the middle of the season the leaves assume a mottled appearance, yellow spots appearing over areas farthest removed from the veins. These spots gradually enlarge and become brownish, and finally the whole leaf curls up and becomes somewhat blackened and ragged. Leaf shedding follows rapidly, leaving the stalk bare. Since most of the leaves are shed prematurely, the bolls fail to develop properly, and the lint is of inferior quality.

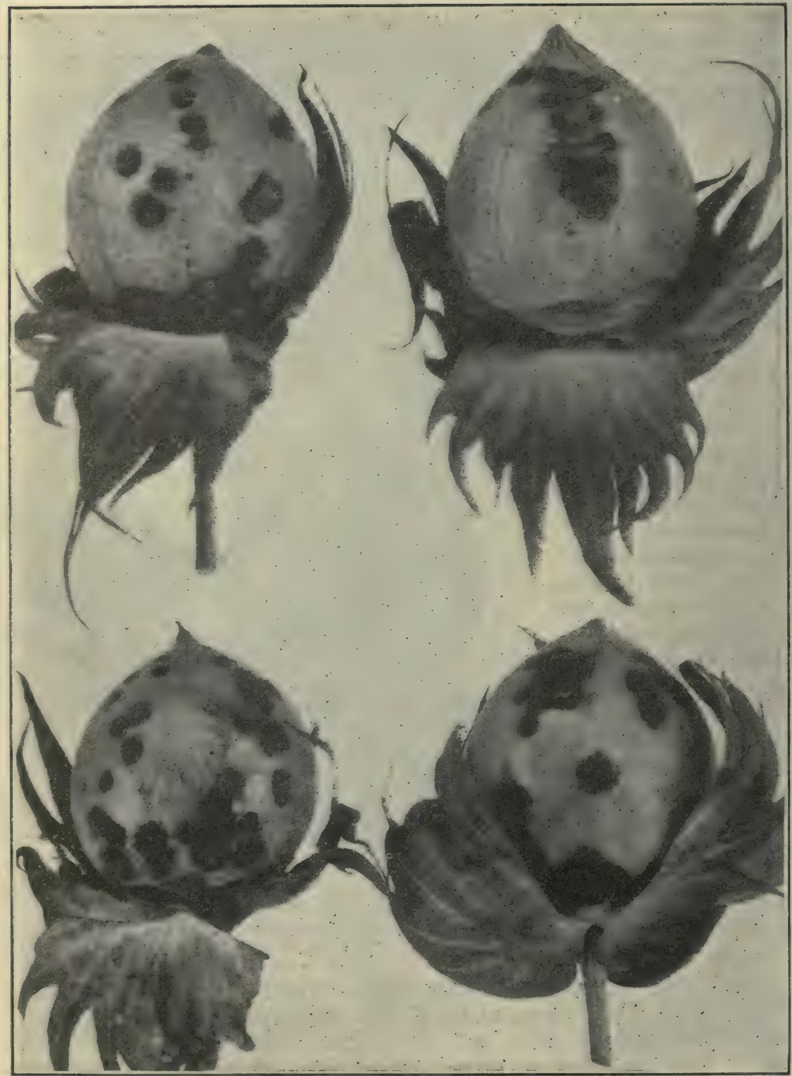

FIGURE 20.—Bacterial boll rot, showing dark, round, sunken spots.

Rust usually develops in definite spots (fig. 21) or in irregular areas in cotton fields, and, unless remedial measures are applied, it occurs year after year in the same places.

Many injuries that cotton planters ascribe to rust are caused by leaf mites, popularly known as red spiders. These mites attack and cause a reddening of a part or all of the leaf. In extreme cases defoliation of affected plants results. The mature red spiders or the yellowish younger ones, together with their fine webs, can usually be found on the under side of the discolored leaves, and thus the trouble can be distinguished from rust.

Rust is caused by soil conditions unfavorable for the proper growth and development of the cotton plant. It is not due to the attack of any disease-producing organism or to injury caused by insects, although the leaves of affected plants become weakened and later are usually attacked by a number of secondary organisms which hasten defoliation. Soil deficiencies largely responsible for rust are (1) lack of humus or vegetable matter in the soil, (2) lack of potash, and (3) improper drainage. Serious outbreaks of rust usually occur in fields with these deficiencies after prolonged periods of drought have been broken by heavy rainfall.

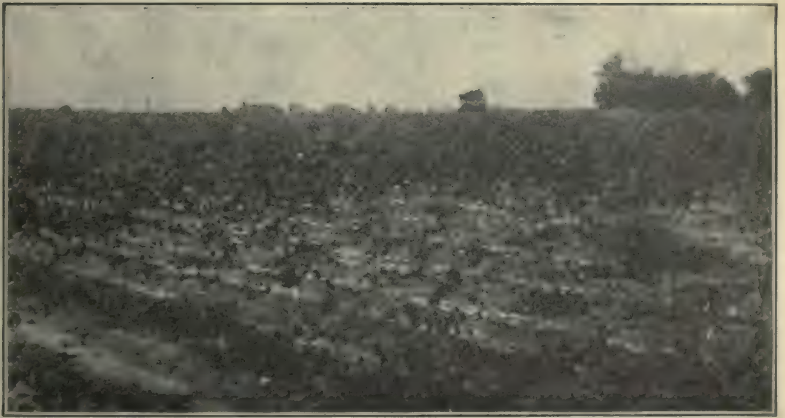

FIGURE 21.—Cotton rust as shown by irregular spots in the field, where but little cotton is produced.

Rust is best controlled by building up soil fertility. Rotation, green-manure crops, such as rye, cowpeas, soybeans, Austrian peas, or vetch, together with barnyard manure, to increase soil vegetable matter, and the use of potash[9] or fertilizers containing potash (4 to 6 percent) will reduce rust damage on most soils.

CRAZY TOP (ACROMANIA)

A growth disorder of cotton plants, commonly called crazy top and also termed acromania, occurs in Arizona and California. The term "crazy top" describes the unusual abnormalities of branching and fruiting in the upper parts characteristic of the disorder. In certain seasons crazy top has caused serious financial losses on account of the sterility of many plants and resulting low yields. Both Egyptian and upland varieties are affected.

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[9] Fifty pounds of muriate of potash per acre or the equivalent from other potash sources should be used.

A striking feature of the disorder is the abnormal habit of branching. The fruiting branches in the upper portion of the plants are frequently replaced by vegetative branches, and the strong upright growth of these in their abnormal positions is responsible in large part for the peculiar appearance of affected plants. One of the first symptoms is a general shedding of buds and young bolls. In some cases this may not begin until some of the lower branches and bolls have almost completed normal development. Late in the season many affected plants that are nearly sterile may set a late crop of bolls on the upper branches (fig. 22). The leaves may be rounded,

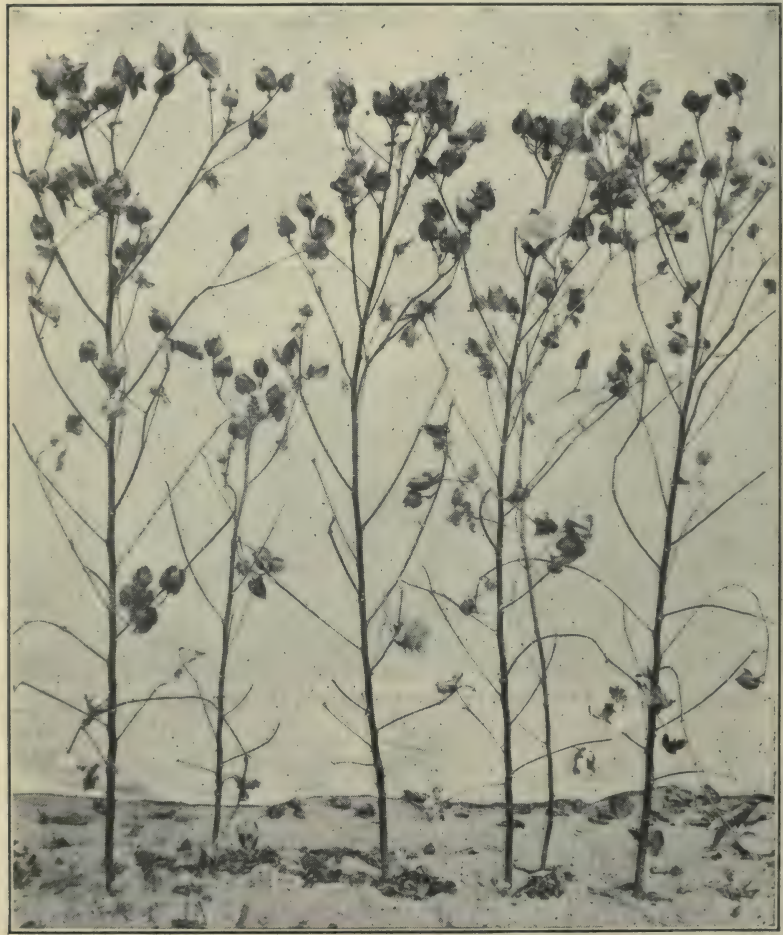

FIGURE 22.—Appearance of crazy top in Pima cotton plants late in the season with leaves removed to show the excessive top growth, stiff, erect branches, and the sterility of the lower fruiting branches.

cupped, and thickened; the flowers small and likely to be imperfect, with stigmas depressed and anthers which fail to open or produce pollen. The bolls are likely to be small and malformed. But few seeds develop, and the lint is likely to be short and weak.

The actual cause of crazy top is not known, but it has been observed that severe crazy-top symptoms are associated with soil and cultural conditions that are unfavorable for the normal growth and development of the cotton plant. The more striking and injurious manifestations of crazy top are found in cemented soils, soils with impervious strata, and areas continuously cropped to cotton. The disease is rare in cotton grown on fine-textured alluvial soils or where cultural practices favorable for optimum growth have been regularly followed.

Cultural practices which tend to effect an even distribution of moisture and which deepen the root zone so that intermittent periods of stress and rapid growth are prevented during hot weather are effective in reducing crazy-top injuries. Rotation with alfalfa is one of several ways to meet this requirement.

MAGNESIUM DEFICIENCY

Magnesium deficiency in cotton occurs in many sections of the Cotton Belt, especially in the mid-Southern and Southeastern States. This deficiency is indicated by a purplish-red color of the leaves between the green veins. The lower leaves are first affected. Late in the season it is sometimes difficult to distinguish between the color due to magnesium deficiency and the color due to maturity of the leaf, although the color due to maturity is apt to be orange, whereas the color due to magnesium deficiency is purplish red.

Magnesium salts, such as magnesium sulphate, double sulphate of potash-magnesium in the fertilizer, or the addition of dolomitic limestone to the soil—broadcast at the rate of 1,500 pounds per acre—have been found to be effective in preventing magnesium deficiency.

SORE SHIN (DAMPING-OFF)

Sore shin or damping-off of cotton occurs widely wherever cotton is grown. It is perhaps more prevalent in heavy soils or those high in organic content, especially during cool wet weather when the land cannot be cultivated. It is primarily a disease of small seedlings, causing them to rot partly or completely, near the surface of the ground. It does not often cause serious damage in the principal sections of the Cotton Belt, though occasionally it reduces stands enough to require some replanting, particularly during unfavorable seasons in the Southwestern States, where the night temperatures during the spring are unusually low.

Cotton seedlings infected with sore shin first show dark to reddish-brown sunken cankers on the stems near or below the soil line (fig. 23). In severe outbreaks the cankers may encircle the stem and penetrate so deeply that the plants fall over and die. Frequently, however, on the return of warm, favorable weather many plants recover and outgrow the injury, unless they are so seriously injured that the normal functioning of the root system is destroyed.

Sore shin is caused by a fungus (*Corticium vagum*), which seems to be present everywhere in the soil but which attacks the cotton plant only under conditions particularly favorable to the fungus and unfavorable to the plant (cold, moist weather).

No very satisfactory control methods are known. The best practice is to fertilize the plants liberally so as to give them a vigorous start. Owing to the habits of growth of the fungus in the soil, crowding of plants in the hills of the rows after thinning should be avoided.

It usually happens that where one seedling in a cluster becomes infected the other plants in the group are almost sure to contract the disease, and there is a greater likelihood that the entire hill of plants will be destroyed than that a portion of them will survive. Where sore shin is a factor in reducing stands, planting the cotton in drills is preferable to planting in hills. This method also gives greater chance of better spacing from surviving plants than does the hill system.

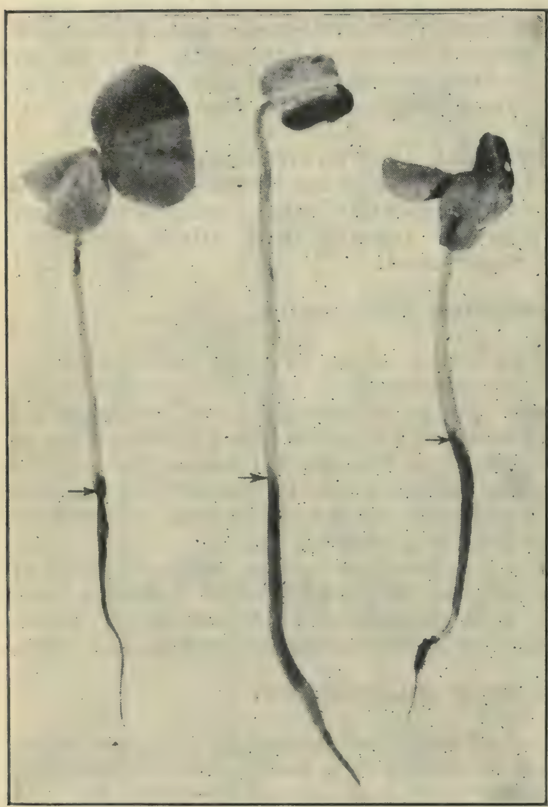

FIGURE 23.—Cotton seedlings infected with the sore-shin fungus. Dark reddish-brown sunken cankers are seen at points indicated by arrows.

ASCOCHYTA BLIGHT

Ascochyta blight is a relatively new disease of cotton, first reported in this country in northwestern Arkansas in 1920. Since its first discovery the disease has been found in South Carolina, Virginia, North Carolina, Alabama, and Mississippi. In some fields 50 percent of the plants have been affected. In severe cases plants are completely defoliated.

Rather large rounded to irregular spots are formed on the leaves. These enlarge rapidly in humid weather and present at first a slightly grayish water-soaked appearance, later turning light brown or tan with a reddish-brown border.

On the bolls and stems the spots are usually similar in appearance to those on the leaves but are darker in color. Stem infections are generally most conspicuous and occur most often at the bases of the leaf petioles. The spots, at first dark brown, enlarge rapidly and become sunken and light brown in the center. They advance up and down the stem much more rapidly than around it. The bases of the leaf petioles are soon surrounded, the leaves droop and die, and the stem itself is soon encircled, whereupon the parts above die and dry up. Early decay and the falling out of the centers of diseased stem spots are characteristic. The boll spots are similar to the stem spots except that the centers are darker. When the fungus is advancing very rapidly a dark-green water-soaked area surrounds the brown portion of the spot. Dry weather may check the external advance of the fungus, but the boll continues to rot internally.

Ascochyta blight is caused by a fungus (*Ascochyta gossypii*) which attacks all parts of the plant aboveground. The fungus is able to infect leaves, stems, and bolls without any apparent previous wounding of the tissues. In practically every instance serious outbreaks have occurred early in the season during periods of excessive rainfall and high humidity. The occurrence of dry and warmer weather results in checking the disease and its final disappearance and the recuperation of all plants not too severely injured. In most cases, except where plants are killed outright, they recover sufficiently to produce a fair crop. The resulting loss, therefore, is generally less than might be estimated at the time the disease is active.

The disease is new, and little work has been done on control methods. It has been proved, however, that the causal fungus can live over winter on dead, diseased stalks in the field and infect cotton the following spring. Crop rotation is suggested as the most evident remedy at the present time.

LIGHTNING INJURY

Lightning injury to cotton, while not a disease, is a common cause of dead spots in cotton fields and warrants brief mention. These spots, usually seen after midseason, are roughly circular in shape (fig. 24, *B*) and vary in diameter from 1 to 3 or more rods. In the center the plants are usually all killed, and the leaves and stems soon turn black, the leaves clinging to the plants for some time (fig. 24, *A*). Between these dead plants in the central area and the surrounding uninjured field there is usually a zone of plants showing diminishing degrees of injury. Some of these plants live for several days, their leaves meanwhile becoming yellow, then brick red, and the plants finally turning black and dying. Others, though injured, live through the season and produce a partial crop.

MINOR DISEASES

In addition to the major cotton diseases already discussed, there are a number of diseases of lesser importance. Several of these occur regularly every season, while a few are encountered only occasionally in localized areas. They cause a certain amount of damage that is difficult to estimate. Only the more important will be mentioned.

LEAF DISEASES

Leaf blight is caused by a fungus (*Alternaria* sp.) which produces an abundance of papery, rusty-brown spots of irregular shape which vary in size from one-eighth to one-half inch in diameter. As these spots enlarge they form a series of concentric markings that are quite prevalent on the leaves during the latter part of the season (fig. 25).

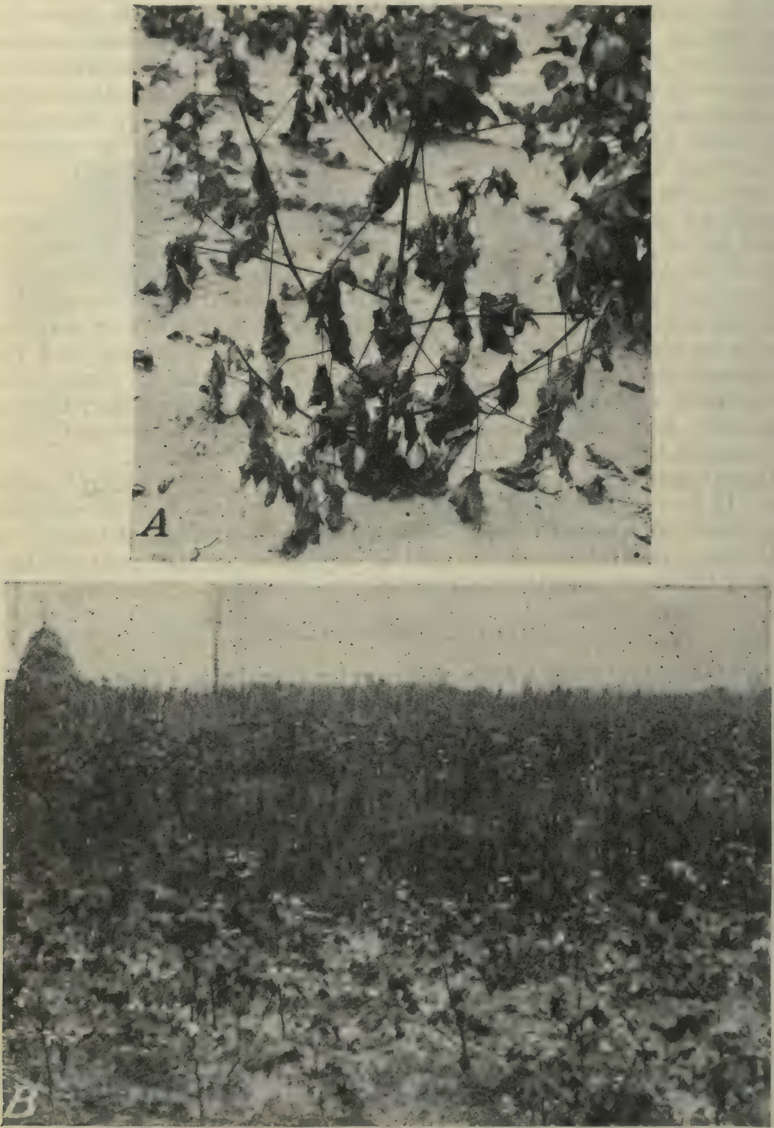

FIGURE 24.—*A*, Cotton plant killed by lightning; leaves and bolls still clinging to the branches; *B*, lightning injury in cotton field showing circular areas, about in the middle of the photograph, where plants were killed by lightning and weeds have grown.

This disease appears in many cases to be associated with potash hunger or rust injury and often causes severe defoliation. It also follows injuries caused by angular leaf spot and red spiders.

Leaf spot, due to the attacks of the *Cercospora* fungus (*C. gossypina*), is extremely common in almost every cotton field toward the end of the season. The spots caused by *Cercospora* are usually small, rarely more than one-fourth of an inch in diameter, and are roundish to irregular in shape. Distinctive features are purple borders and white centers. After reaching maximum size the centers of the spots often fall out, producing a shot-hole effect. This fungus may attack uninjured tissues, but it seldom causes as much defoliation as the alternaria leaf blight.

Frosty blight, also called areolate mildew, occurs on the leaves of plants growing in damp places, especially toward the end of the season. The spots are small, angular in shape, and are typically white on the under side of the leaves (fig. 26), owing to the presence of fruiting bodies of the causal fungus (*Ramularia areola*). The disease, although conspicuous, causes little damage.

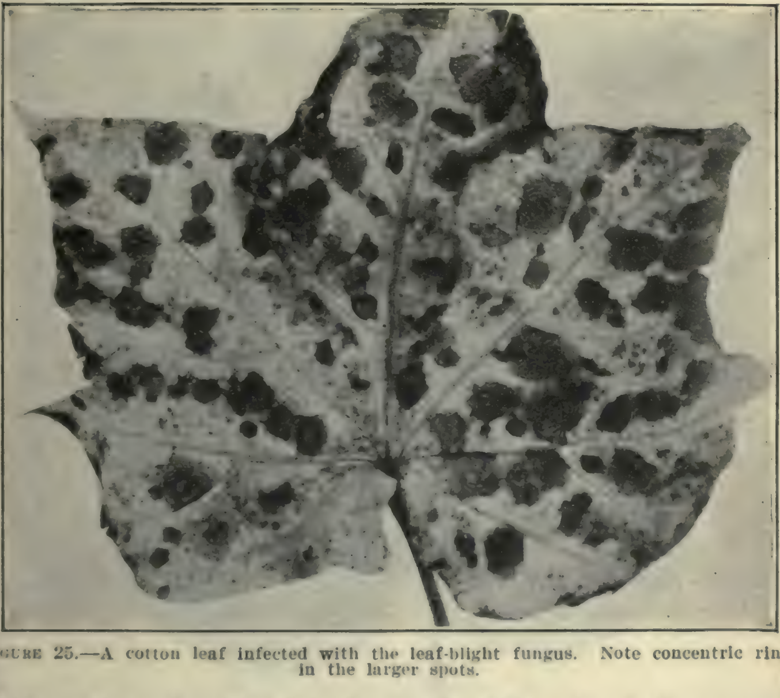

FIGURE 25.—A cotton leaf infected with the leaf-blight fungus. Note concentric rings in the larger spots.

The true rust of cotton is caused by one or the other of two fungi. One rust (*Kuehneola gossypii*) is characterized by the presence on the leaves of numerous slightly raised, rusty brown, circular spots about the size of a pinhead. This disease occurs in Cuba and Puerto Rico and has been reported once from Florida. The other rust, *Puccinia hibisciata* (*Aecidium gossypii*), causes larger raised orange-colored spots on the leaves, bolls, and involucral bracts, and occurs to a limited extent in Texas, Arizona, New Mexico, and southern California. Both are distinctly different from the disease commonly called rust, previously described (p. 23).

BOLL DISEASES (ROTS)

Diplodia boll rot is often destructive during wet seasons in the Mississippi Valley, particularly in Louisiana and Mississippi. In Louisiana damage sometimes reaches 10 percent, and the loss in that State averages about 2 percent. This boll rot, although present in the southeastern cotton States, is not so destructive there. It is caused by a fungus (*Diplodia gossypina*) which usually attacks the bolls from the stem end and gains entrance into the tissues through weevil or other punctures or through injuries resulting from other diseases. After entering, the fungus develops rapidly and quickly destroys the boll. When the boll has rotted tiny blisters appear on its surface, and from these, black sooty masses of spores are released and cover the whole surface of the boll. They are then scattered to other bolls that may be punctured or otherwise injured and new infections result. The lint from diplodia-rotted bolls is usually matted, smutty, and worthless. As a rule this boll rot causes greater damage to the lower bolls in contact with the soil, and damage is greater in the lower fertile areas in fields, where rank vegetative growth occurs. The disease is not seed-borne. Rotation of crops and thorough weevil control are suggested as control measures.

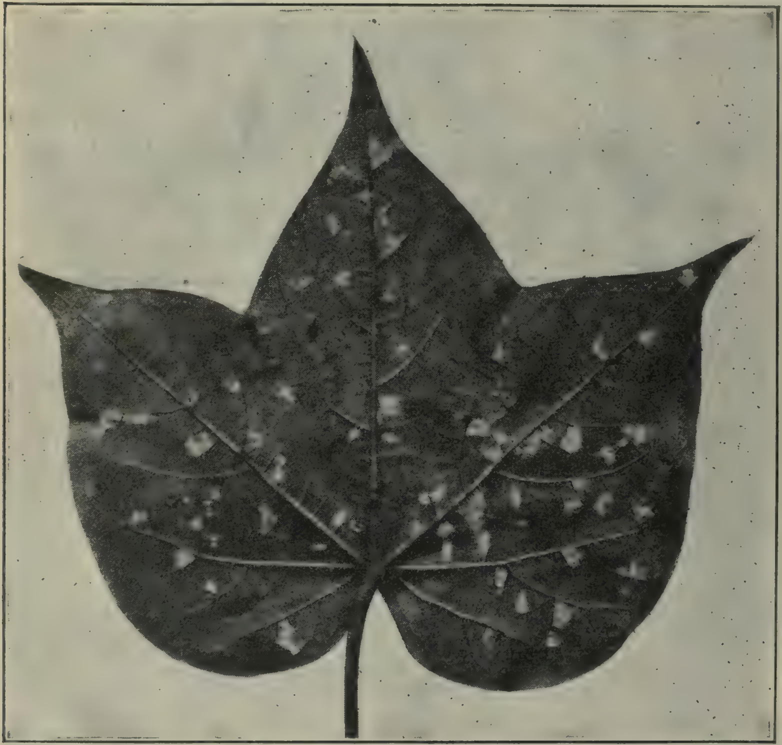

FIGURE 26.—Under side of a cotton leaf attacked by areolate mildew, or frosty blight.

Other common boll rots are those produced by species of *Fusarium* (chiefly *Fusarium roseum* and *F. moniliforme*). One produces a pink rot of both the boll and the lint. Light pink masses of spores occur on the surface of the rotting bolls. This differs from the anthracnose rot in that the spore masses are not slimy or confined to the center of the spots. The spores are produced as powdery masses over the entire diseased portions of the boll and are a lighter pink than the anthracnose spores. The fungus lives over in the field as well as on the seed and lint and may produce spots on the young seedlings in the spring.

Two boll rots, which frequently occur in many sections of the Cotton Belt, are caused by the mold fungi *Aspergillus niger* and *Rhizopus nigricans*. Both are largely wound parasites and are frequently referred to as smut of bolls, especially in their later stages. The aspergillus rot occurs especially in the Southwest.

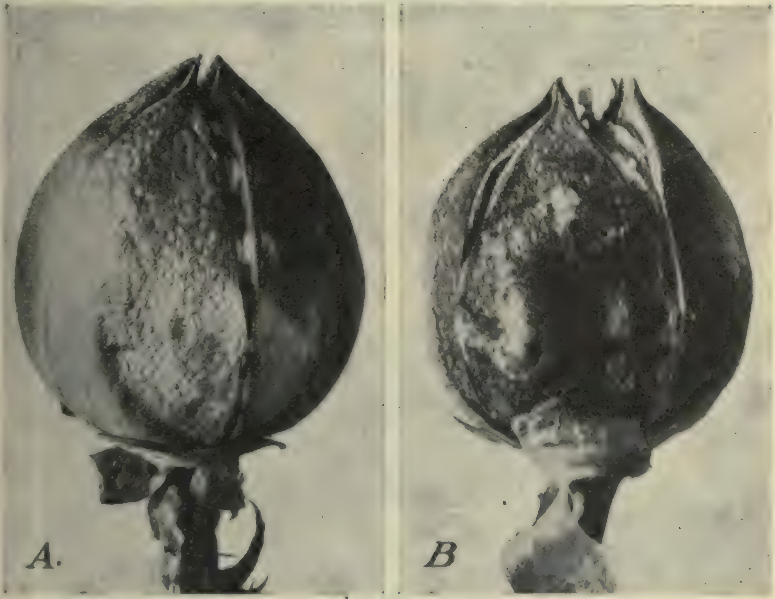

FIGURE 27.—Cotton boll rot caused by *Aspergillus* (*A*) and *Rhizopus* (*B*).

The typical symptoms of the aspergillus decay follow: The rot begins as a soft, pinkish spot either on the side of the boll or somewhere near its base. The hue and the extent of the pink discolorations vary more or less, but the discoloration is always present and is characteristic of this sort of decay. As the lesion varies in size, the color of the older decayed area turns from pink to brown (fig. 27, *A*) and the original discoloration remains only in the freshly decaying regions; that is, on the border of healthy and diseased tissues. If such a boll is cut open through the affected area the same pink to purplish and red-brown shades of the invaded tissues will be seen. The fungus may destroy all parts of the boll, including the seed and the lint. It produces an abundance of spores in the affected area, which soon becomes dark and gives the bolls a smutty appearance. If the entire boll is rotted it dries up and remains closed, but if the progress of the disease is checked for some reason or other the bolls may open partially.

The rhizopus rot lacks entirely the pink discoloration characteristic of the aspergillus decay. The affected portions of the boll are olive-green in color and retain this uniform discoloration until the decayed parts dry up, at which time they become darker (fig. 27, *B*). The spore masses are not quite so dense as those produced by the *Aspergillus* and form a dark-gray or blue-gray rather than a sooty black powdery film over the boll.

Infection of the boll by either of the above-mentioned two fungi depends on injuries caused by insects, the most noticeable of which are those caused by the bollworm and the bollweevil. Cases have also been observed in which these two boll rots have followed injuries made by anthracnose and bacterial boll rot. Therefore, reduction in the damage that they indirectly cause depends on control of insects and other diseases.

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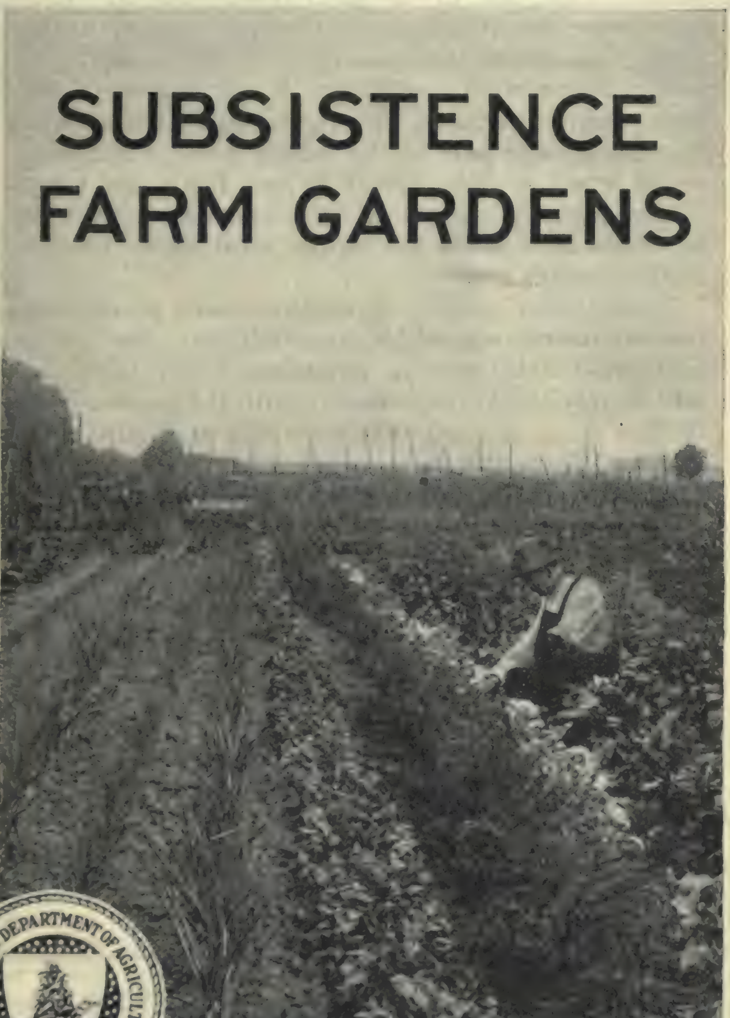
SUBSISTENCE FARM GARDENS



VEGETABLE GARDENS are an important factor in any subsistence-farming enterprise on account of the large amount of food that can be produced on a small area devoted to vegetables. Fruits, while not of as great food value as vegetables, are essential because they add variety to the diet. Combined with poultry and dairy products, and, under certain conditions, the production of the home supply of meats, the garden and orchard will furnish a large part of the family living. Furthermore, when a family grows its own fruits and vegetables more liberal use of these essential foods will be made than when the supply must all be bought in the market.

Under most conditions one-half acre planted to miscellaneous vegetables, one-half acre in fruits, and one-fourth acre in potatoes or sweetpotatoes will supply the average family with the greater part of this class of food that they will normally consume. Where the entire subsistence homestead operation is limited to an acre at least one-half of the area should be devoted to the garden and small fruits, but whenever the plan includes 3 to 5 acres, 1½ to 2 acres can be profitably used for the production of fruits and vegetables. This, however, will include a limited number of trees of the standard tree fruits.

Men who are employed only part time or short hours will have ample time during the spring and summer months to plant and tend a garden. Careful records have shown that under favorable conditions the time spent in the garden yields a return equal to that obtained for a corresponding period of time devoted to regular employment.

Washington, D. C.

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SUBSISTENCE FARM GARDENS

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INTRODUCTION

FRUITS AND VEGETABLES will naturally form an important part of the diet of families undertaking subsistence farming as a means of supplementing their food supplies and occupying their spare time. The supply of fruits and vegetables in most cases will be produced by methods differing more or less from those employed in regular farm gardens. This bulletin has been prepared with the limitations clearly in mind, under which the average subsistence homesteader is working, and includes brief cultural directions for about 20 of the most important garden vegetables, 5 of the small fruits, and 5 of the standard or tree fruits. The information contained herein applies mainly to climatic and other conditions prevailing in the Northern and Eastern States; the bulletin is not intended for distribution in the Cotton States, the Great Plains region, or the Pacific coast region. More complete cultural information may be obtained from the regular gardening bulletins of the United States Department of Agriculture and the State colleges and experiment stations.

SOILS AND FERTILIZERS

Land that is available for subsistence farms may not always be of high quality or fertility, and every expedient will be necessary in order to produce reasonably good crops of fruits and vegetables on it during the first few years. In the course of time the land may be improved and made more productive. In any case the best land available should be selected for the garden. Where poultry or a cow is kept as a part of the subsistence-farming plan, the manure can be used to advantage on the garden and truck patch. In the absence of manure, certain soil-improving crops such as soybeans, clover, or even rye, can be grown and turned under to add humus to the soil. The moderate use of commercial fertilizer is recommended wherever it is obtainable and its use would be justified by increased production.

Wherever there is opportunity to choose the location of the vegetable garden, a southern or southeastern exposure should be selected; locations on low ground or where there is any danger of overflow should be avoided. Good drainage is important because wet soils are usually unproductive and cannot be worked early in the spring. Sandy loams and light clay loams are considered best for growing vegetables, but heavy clay loams can be made to produce good yields of most garden crops if they are lightened and improved by the addition of manure or some other form of organic matter. Composts of leaves, straw, and other waste products are often cheap sources of humus. Ten tons of manure will not be too much to plow under to improve the soil of a half-acre garden at the start, and this can be supplemented by applications of 4 or 5 loads of partly rotted manure each season if the manure can be secured. Poultry manure should be saved during the winter and kept dry, then spread on the garden early in the spring. It must be remembered that poultry manure is quite strong and must be used sparingly when applied near the plants. Sifted coal ashes or sand may be used moderately to lighten stiff clay soils.

Commercial fertilizers are an excellent source of nitrogen, phosphorus, and potash (three important elements needed by plants), but the value of the fertilizer depends almost entirely upon the amounts of these essential ingredients that it contains. Four hundred to five hundred pounds of a high-grade garden fertilizer such as one having a guaranteed analysis of 5 percent nitrogen, 10 percent phosphorus, and 6 percent potash, or some similar mixture, will generally be sufficient for a half-acre garden, especially if the land has been manured. Some crops like corn, potatoes, cabbage, onions, and lettuce require more fertilizer than snap beans, tomatoes, and peas. A portion of the fertilizer can be applied when the land is being fitted for planting; then the remainder can be used for top-dressing or side-dressing along the rows of plants during the growing period.

PREPARING THE SOIL FOR PLANTING

The depth to plow or spade the garden will depend upon the character and the depth of the surface soil. Where the topsoil is 8 or 10 inches deep it should be worked to that depth, but where the topsoil is less than 6 inches deep, care should be taken to avoid bringing any considerable amount of the subsoil to the surface, although it is a good plan to loosen the subsoil 6 to 8 inches deeper than the topsoil is turned. This can be done by the method known as trenching. Trenching should be done in the fall and early winter at such times as the condition of the soil and weather are suitable. The work of trenching may be made much easier if the land is handled in strips. Beginning at one side of the plot to be trenched the topsoil of a strip about 2 or 2½ feet in width is taken off and piled at one side. The subsoil is then broken as deep as possible with ordinary garden tools and then the topsoil from the adjoining strip no. 2 is thrown over to form the topsoil on strip no. 1. The subsoil of strip no. 2 is then broken up and the topsoil from strip no. 3 is turned over upon strip no. 2 and so on until the far side of the plot of ground is reached; then a wheelbarrow is employed and the topsoil from strip no. 1 is carted across and becomes the topsoil of the last strip to be worked. This involves considerable work but greatly improves the character of the soil, and can often be done a little at a time. Coarse manure, cleanings from the poultry house, or almost any form of compost or organic matter may be worked into the subsoil to loosen and improve it.

Where the garden is plowed with a team or tractor the soil should be harrowed very soon after plowing, in order to pulverize the lumps. In case the garden is spaded it is a good plan to break the lumps with the edge of the spade or spading fork as each spadeful is turned, and when a strip 5 or 6 feet in width has been spaded, the soil should be well raked to break the remaining lumps. The secret of getting a good seedbed is to pulverize the soil to the full depth that it is plowed or spaded. Under no circumstances should the soil be plowed or spaded when it is so wet that it will stick together in a ball when a small amount is squeezed in the palm of the hand, as being worked while wet will cause the soil to bake and become hard. Sandy loam soils can be worked sooner after a rain or irrigation than heavy clay soils, but even the sandy soils are injured if worked when they are too wet. After plowing, the soil may require repeated harrowing or dragging to break the lumps and make it fairly firm, as a very loose soil soon dries out and causes the plants to suffer for moisture.

WATERING THE GARDEN

The use of water on gardens will prove of benefit at some time during practically every gardening season; the method of applying it will depend upon the source of supply, the character of the land, and various other factors. In some cases water can be pumped from a spring, a well, or from a small stream; in other cases the water can be drawn from a city or town water supply, but the main point is to apply it when it is needed, and to give the plants enough to do them some real good. Market gardeners frequently employ overhead sprinkler systems for applying the water; others use the furrow system, running the water in small streams along the rows of plants; while in still other cases where the land is perfectly level the surface may be flooded and then the surplus water drawn off. Of these three systems the one where the water is run in the small furrows along the rows is perhaps the most satisfactory for use in the subsistence garden. Under no conditions should the plants be sprinkled at frequent intervals, but the soil should be allowed to become reasonably dry and then given a thorough wetting, after which no more water will be required until the soil again becomes slightly dry.

Water, even in small quantities, is a great help in the setting of plants in the garden. The proper method of applying the water is to dig the holes and set the plants in them with a small amount of soil packed rather firmly about the roots. From a pint to a quart of water should then be poured into the hole and allowed to settle into the soil; the hole should then be filled completely with the soil in its natural state. In case newly set plants are given a second watering a day or two after being set, small pockets or holes should be made alongside of the plants and these should be filled with water; then, after the water settles into the soil the holes should be filled with soil.

Where water is supplied from a hose it should be allowed to run in a soft stream between the rows rather than to be thrown forcefully from a nozzle. The average subsistence gardener will be dependent upon local water supplies from wells or streams, and very simple methods of distributing the water should be worked out.

Mulching around the plants with straw or coarse manure or any material of like character will aid materially in conserving moisture during dry periods.

SEEDS FOR THE GARDEN

Seeds for the subsistence garden should always be arranged for and on hand well in advance of the planting season. In many cases the orders for garden seeds are pooled by groups of gardeners, and this results in considerable saving in the cost to the individual gardeners. Under normal conditions the seeds required to plant a half-acre garden, exclusive of seed potatoes and sweetpotato plants, will cost from $3 to $5, but by purchasing in quantity the necessary seed supply may often be obtained for $2 to $3. The cost of seeds, however, depends very largely upon the crops planted. If considerable quantities of peas and beans are planted the seed bill will be relatively high, as these are among the most expensive items in the seed budget. Seed potatoes are one of the most expensive items, but a small saving can be made when the potatoes are purchased in quantity and distributed to the various gardeners. In the case of sweetpotato plants the southern-grown plants can often be used, or a number of gardeners may combine in the construction of a small furnace-heated plant bed in which to grow their supply of sweetpotato plants. In purchasing seeds for the subsistence garden only high-grade seeds should be considered, even though the cost may be a little more. The use of poor seeds is very frequently the cause of failure and disappointment and low-grade seeds should not be used under any conditions.

Seedsmen who supply the seeds for subsistence gardens should be required to give guaranty as to both the germination and the general quality of the seeds furnished.

When the seeds are received they should be carefully unpacked and checked and kept where they will be reasonably dry and at about a living-room temperature, also where there will be no chance of mice or rats destroying them.

Any seeds that are left from the planting of the garden should be carefully kept. Certain kinds of seeds will keep over from year to year, or second or even third plantings of some of the vegetables may be desirable. In some cases gardeners have been very successful in the saving of certain seeds from their own gardens. This is true of peas, beans, tomatoes, cucumbers, squashes, melons, and several other of the vegetables that form their seeds the same season that the crop is planted.

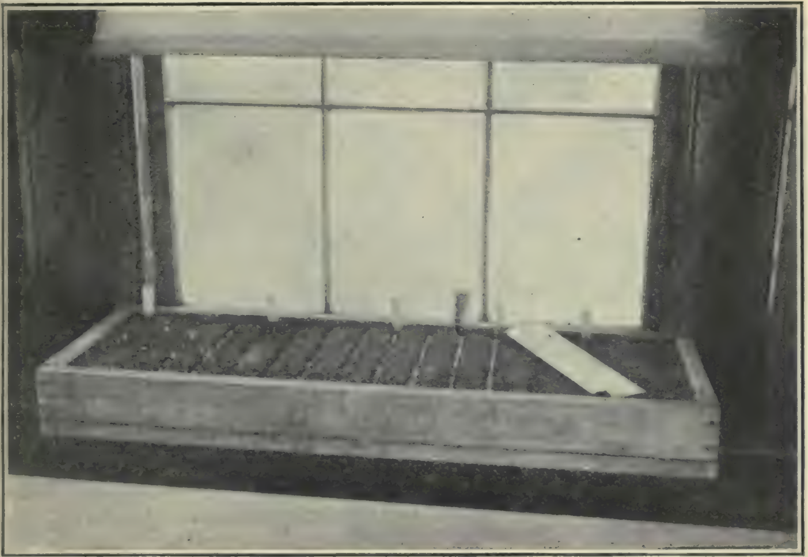

FIGURE 1.—Window box for starting early plants in the house.

The particular variety of any crop to plant will depend somewhat upon local conditions, and the inexperienced gardener should always seek the advice of the county agent or some local gardener who has had years of experience in the growing of vegetables for home use.

Recently there have been developed a number of varieties of disease-resistant vegetables, and these should be used whenever there is any reason to believe that the diseases to which the varieties are resistant may be present in the soil. Certain diseases are carried with the seed, but the average gardener has very little control over this except that he may insist upon being furnished with seed that has been treated for the control of these seed-borne diseases.

STARTING EARLY PLANTS

Earliness is of very great importance with a number of the transplanted crops like tomatoes, peppers, lettuce, and cabbage. Considerable time can often be gained by starting the plants in the house, using a window box of the type shown in figure 1. The window box can sometimes be supplemented by the use of a small coldframe, such as is shown in figure 2. By the combination of the window box and the coldframe all of the early plants required for planting in the garden can be grown and ready to set out by the time the weather is warm enough. If the gardener is compelled to wait until the plants can be grown outdoors much valuable time will be lost in getting the crops ready for use.

A box or tray in which to start early seedlings should be about 3 inches deep and of the right size to fit into a south window of the living room or kitchen. Any good, light soil will do for starting the plants, but it should be sifted and enough old-rotted manure mixed with it to make it hold moisture and be rich enough to insure a good growth. The seeds may be sown in rows as indicated in figure 1, and they should be covered just deep enough to insure the proper amount of moisture to make them germinate. Care must be taken that the little seedlings are not overwatered, as an excess of water will often cause the appearance of a disease known as "damping off" which causes the plants to rot off at the surface of the ground. Careful watering and plenty of air and sunshine will ward off this disease.

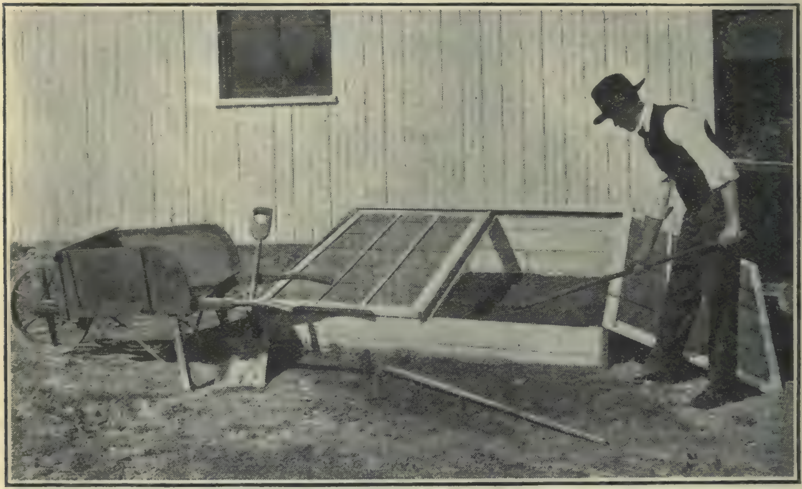

FIGURE 2.—Preparation of a sash-covered frame for starting early plants.

When the plants have formed about one leaf in addition to their two seed leaves they should be transplanted to other boxes of soil or to the coldframe where they will have more room to spread out and develop plenty of roots. Later when the weather becomes warm the plants will be ready for planting in the garden. The coldframe may need to be protected during cold nights by spreading old matting, burlap bags, straw, or regular hotbed mats over it. On bright, sunny days the bed must be opened and the plants given a reasonable amount of air because if the temperature is allowed to run too high the plants will grow weak and spindling; in fact, 60° to 70° F. is about the right temperature for growing most plants.

Glazed sash 3 by 6 feet in size are the best covering for a coldframe, but heavy unbleached muslin makes a fair covering and it can be kept rolled up and off the bed during bright warm days and put on again before the plants become chilled as the sun goes down.

TOOLS

Elaborate or expensive tools are not necessary for the cultivation of a subsistence garden. For a small garden, that is, one-fourth acre or less, a spade or spading fork, a hoe, a steel rake, a line for laying off the rows, a garden trowel, and a watering can will be sufficient. For a one-half acre garden it will be desirable to have a wheelbarrow on the place and also a wheel hoe or hand cultivator of the type shown in figure 3. A combination wheel hoe and seed drill is desirable for use on gardens of one-half acre to an acre. On subsistence gardens where a horse is kept it is desirable to include a one-horse cultivator having several sizes of shovels and sweeps, as shown in figure 4. It pays to secure tools of good quality, then give them proper care, clean them after they are used, and keep them stored in a dry place. If this rule is followed the tools will remain in good condition for many years.

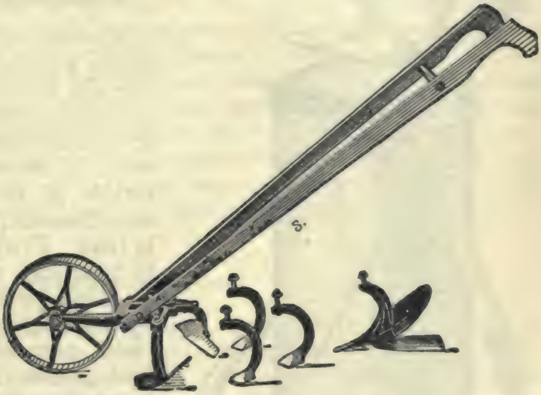

FIGURE 3.—A small hand cultivator, a desirable addition to the garden equipment.

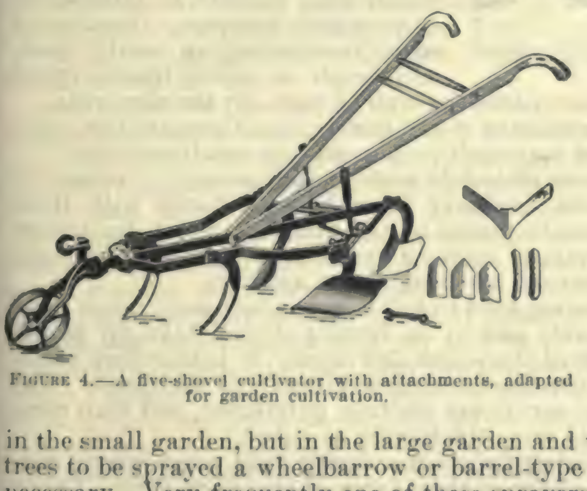

FIGURE 4.—A five-shovel cultivator with attachments, adapted for garden cultivation.

Some form of sprayer or duster will be required for the control of diseases and insects. The air-pressure sprayer shown in figure 5 is one of the best pieces of equipment for use in the small garden, but in the large garden and when there are fruit trees to be sprayed a wheelbarrow or barrel-type spray pump will be necessary. Very frequently one of these sprayers will serve for three or four gardeners and may be owned jointly or, what is perhaps a better plan, will be owned by one of the gardeners and a small charge made for its use. There are several forms of dusters on the market, including the plunger, fan, and bellows types. The main point in selecting spraying and dusting equipment for use in the garden is to have attachments that will deliver the spray or the dust on the underside of the leaves. This is especially desirable for the control of aphids, Mexican bean beetles, and other insects that work mainly on the underside of the leaves.

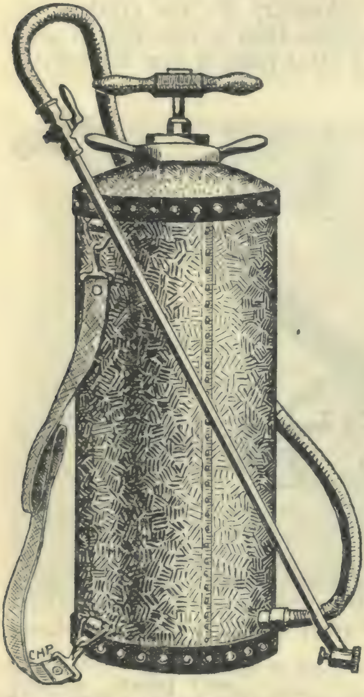

FIGURE 5.—A compressed-air sprayer suitable for larger gardens.

DISEASE AND INSECT CONTROL

Anyone who plants vegetables or fruits without making definite plans for the control of insect pests and diseases is headed for sure failure. It is not necessary to spend large sums of money for advertised materials in order to control insects and diseases; quite often the reverse is true. Frequently a home remedy, if properly applied, will give just as much protection. Hand picking of the larger insects has been practiced ever since man planted his first garden, and when this practice is persistently followed the need for expensive poisons is lessened. The destruction of the refuse of each crop immediately after it is harvested prevents the continued breeding of large numbers of insects, which may migrate to later crops or to winter quarters. Community effort in cleaning up weeds, trash, and brush in which insects spend the winter will greatly reduce the crop of pests for the next year.

When it becomes necessary to use insecticides, there are two main types to be considered—stomach poisons and contact insecticides.

Stomach poisons are materials used to kill insects by poisoning their food. It is not necessary to strike the insects with these poisons, but they must be placed on the plants on which the insects feed. The most common stomach poisons are paris green, lead arsenate, calcium arsenate, and magnesium arsenate.

Contact insecticides are used to kill insects which suck juices from the inside of the plants and by so feeding do not take up poison placed on the surface of the leaves and stems. It is therefore necessary to apply a contact spray or dust directly to the insect. The most common contact sprays are nicotine, pyrethrum, and soap combinations. Nicotine is very widely used as a dust.

Owing to their peculiar habits of securing food, some insects cannot be controlled by either of these types of sprays or dusts. Other materials, therefore, such as bichloride of mercury, bordeaux mixture, and poisoned bait must be resorted to. To avoid arsenical residue on the plants, a material known as "rotenone", which is both a stomach poison and a contact poison, has come into common use. The present source of rotenone is derris and cubé root. The stomach poisons are cheaper and remain on the plants longer; hence they are used whenever possible.

SPRAYING AND DUSTING EQUIPMENT

There are available on the market various types and makes of equipment adapted for use in the home garden. The choice of a sprayer or duster depends on the size of the garden and the amount of money available for such equipment. Generally speaking, a 3-gallon compressed-air sprayer or a duster of the bellows or rotary type is advised. These can be obtained with attachments to place the dust or spray on the underside of the leaves. Small hand atomizer sprayers and plunger-type dusters are too small for the average home garden. Because certain insects feed almost entirely on the underside of the leaves, it is almost impossible to reach them with poisons applied from a cloth bag, sprinkling can, or a can with holes punched in the bottom.

STANDARD REMEDIES

As suggested in preceding paragraphs, there are certain remedies for disease and insect troubles that have become more or less standardized, and one mixture may serve for the control of the diseases or insects affecting several different crops. Furthermore, there are cases, like potatoes, where combination sprays or dusts may be used to control both the diseases and the insects at one application.

Spray materials may be purchased in small amounts from seedsmen, nurserymen, florists, and hardware and other dealers. Directions for use will usually be found on the package; also information as to the nature of the material, whether an arsenate of lead, bordeaux mixture, a nicotine sulphate, a wettable sulphur, etc.

The following discussion includes those spray materials herein recommended for use:

Arsenate of lead is for use in controlling leaf-eating insects. It is purchased as a white powder and is deadly poisonous to man and animals as well as to insects. It is used at the rate of about 1 ounce (2 heaping tablespoonfuls) in 3 gallons of water. It is commonly sold under its own name, or ready-mixed with one of the other sprays, such as bordeaux mixture or wettable sulphur, with which it is commonly used. *This poison should not be used except where washing will remove all spray or dust residues.*

Bordeaux mixture may be made at home as described on page 11. It may be purchased as a dry powder or paste under various proprietary names. If the label on the package states that the active ingredient is copper and that the material is for use on fruit trees, grapevines, potatoes, etc., the buyer may be certain that the contents are bordeaux, regardless of the proprietary name.

Lime-sulphur, a clear, amber-colored fluid, is used in winter at the rate of 1 pint to 1 gallon of water, and during the growing season at the rate of 1 pint in 5 gallons of water. It is sometimes sold in the dry state. One-half pound of the dry material equals 1 pint of fluid.

Nicotine sulphate is useful in the control of sucking insects (plant lice or aphids). It is sold under various proprietary names and can be identified by the analysis on the label. It should be used as described on page 11.

Oil emulsion and miscible oils are sold under various trade names and can be identified by reading the labels. These oils and emulsions are useful in the control of scale insects, and should be applied only when the trees are wholly dormant.

Wettable sulphur is sold under a variety of trade names and can usually be identified by the word "sulphur" in the analysis given on the label, but it should not be confused with lime-sulphur, which is either a clear amber fluid or a powder that forms such a fluid when mixed with water. Wettable sulphur mixed with water forms a white to cream-colored or yellowish fluid. It should be used at the rate of about one-half pound to 5 gallons of water, or as directed on the package.

Sulphur dust is a specially prepared, finely ground sulphur which may be bought by itself and mixed with arsenate of lead at the rate of 9 parts of sulphur to 1 part of the arsenate of lead when needed, or the two may sometimes be bought ready mixed.

Copper-lime dust may be used in place of the bordeaux-mixture spray but is generally not as effective as the spray. It may be bought ready-mixed and with or without arsenate of lead.

STOMACH POISONS

Paris green

Spray:			
Paris green	2 level teaspoons	or	2/3 pound
Hydrated lime	6 level teaspoons		2 pounds
Water	1 gallon		50 gallons
Dust:			
Paris green	1 level teaspoon	or	1 pound
Hydrated lime or flour	1 pint		12 pounds

Calcium arsenate

Spray:			
Calcium arsenate	6 level teaspoons	or	1 pound
Hydrated lime	12 level teaspoons		2 pounds
Water	1 gallon		50 gallons
Dust:			
Calcium arsenate	2 level teaspoons	or	1 pound
Hydrated lime or flour	1 pint		7 pounds

Poisoned-bran bait

Paris green	2 level teaspoons
Wheat bran	5 pounds
Molasses	½ pint
Water	5 quarts

Mix the paris green and dry wheat bran together so that every particle of the bran will receive a coating of the paris green. Dissolve the molasses in the water. Add the liquid to the dry materials slowly and mix thoroughly, making a rather dry mash.

Scatter the bait thinly, about sundown, near plants to be protected. The worms crawl out at night and eat the poisoned bran. If the garden is to be planted where heavy vegetation grew last fall, it would be advisable to scatter bait over the entire garden just before planting.

CONTACT POISONS

Nicotine sulphate

Spray:			
Nicotine sulphate (40 percent nicotine)	1 teaspoon	or	¾ pint
Soap, any kind	1 cubic inch		3 pounds
Water	1 gallon		50 gallons
Dust:			
Nicotine sulphate (40-percent nicotine)	1 ounce	or	3¾ pounds
Hydrated lime	2 pints		50 pounds

Nicotine dust is most effective if applied when the air is still and the temperature high, preferably above 75° F. Nicotine dust must be very thoroughly mixed in order to secure a uniform blending of the ingredients and must be applied as soon as mixed or kept in a tight container to prevent the loss of the nicotine.

FUNGICIDES (FOR DISEASE CONTROL)

Bordeaux mixture

Pulverized bluestone (copper sulphate)	4 level tablespoons or 4 pounds
Water	2 quarts or 25 gallons
Hydrated lime	6 level tablespoons or 6 pounds
Water	2 quarts or 25 gallons

Dissolve the pulverized bluestone in the water in an earthen or wooden vessel. (Bluestone is corrosive to some metals, particularly iron.) Place the hydrated lime in the second portion of water and stir it; then pour the bluestone solution into the limewater while stirring.

Bordeaux mixture should be made fresh for each application. If old bordeaux is applied it may cause injury to plants and result in unsatisfactory disease or insect control.

COMBINATION INSECTICIDES AND FUNGICIDES

Certain combination dusts and sprays may be made and thus control both insects and diseases at one application. For example, arsenical poisons may be added to bordeaux mixture, or both arsenicals and nicotine may be used in combination with bordeaux. To each 3 gallons of bordeaux 1 ounce of calcium arsenate or magnesium arsenate, or three-fourths ounce of paris green may be added. This gives a spray that will control certain leaf diseases and also the insects that eat the foliage. Bordeaux mixture is in itself a repellant for certain insects, and by the addition of 1 teaspoonful of nicotine sulphate to each gallon of bordeaux mixture, reasonable control of leaf hoppers and aphids can be secured in addition to the control of leaf blight.[1]

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[1] For more detailed information on the control of garden diseases and insects consult Farmers' Bulletin No. 1371, Diseases and Insects of Garden Vegetables.

CULTURAL PRACTICES FOR VEGETABLE CROPS

The following brief discussion of cultural practices is intended to cover only the main points in the growing of the various crops. More detailed information can be procured from the bulletins of the United States Department of Agriculture listed at the end of this bulletin. The workers in many of the State colleges and experiment stations have prepared special bulletins containing information especially adapted to those particular States, and subsistence gardeners are advised to write to the extension service of their State college for copies of these bulletins. Success depends largely upon the enthusiasm of the gardener and the painstaking care that he is willing to give his garden or fruit plantings. As already stated, much of the work of the small subsistence farms will be undertaken under difficulties, and no one should become discouraged if he does not attain complete success from the very start.

In the treatment of the crops in this bulletin, those belonging to the vegetable group are handled from the standpoint of the time of planting them in the spring rather than by alphabetical or any group arrangement. It should be borne in mind that the date for planting these crops varies with locality and elevation above sea level. Certain crops, such as potatoes, peas, cabbage, onions, kale, spinach, and lettuce, may be planted before the ground becomes warm or the danger of frost is past; others, such as snap beans, tomatoes, and sweet corn should not be planted until practically all danger of frost is past. Lima beans, peppers, and eggplant should not be planted until the ground has become warm. Wherever there are experienced gardeners in the neighborhood, their advice both as to the time and methods of planting should be sought.

POTATOES

Potatoes are among the most important of the vegetable crops from a food standpoint. For a family of 4 or 5 persons, 10 to 15 bushels are required for the entire year. In the more southern sections a portion of the potato supply can be obtained from sweetpotatoes. Three to five bushels of early potatoes are considered enough for the average family, as early potatoes do not keep long and a late crop is better for winter storage. There are two main varieties of early potatoes, the Irish Cobbler and the Triumph, sometimes called Bliss Triumph.

Potatoes can generally be planted just as soon as the ground is in condition to work because they require from 4 to 6 weeks to come up. This, in many sections of the Northeast, may be as early as March 20; however, the first week in April is considered the time for planting early potatoes in many sections. To the northward the planting date may not be until the middle of May. One peck of seed potatoes will plant 300 to 400 feet of row, the potatoes being cut into pieces having 1 or 2 good eyes, as shown in figure 6. Under favorable conditions this will yield 3 to 5 bushels of potatoes suitable for home use. This will give a basis for calculating the quantity to plant. For a rather large family—6 or 7 persons—at least one-half bushel of seed should be planted for the early crop. By careful cutting of the potatoes this may be made to plant from 700 to 800 feet of row. The seed should be planted in rows 3 feet apart, with the pieces 12 to 14 inches apart in the rows and covered 4 inches deep in light soils and 2½ to 3 inches deep in the heavier soils.

The greatest benefits from the use of fertilizer have been procured where it is drilled along both sides of the seed pieces and at about the same depth as the seed. The fertilizer should be kept at least 3 inches away from the seed pieces. One method of planting potatoes in the home garden is to open a flat-bottomed furrow about 4 inches deep and 8 inches wide. Place the seed pieces in the center and a trickle of fertilizer along each side; then, with the hoe, cover both the seed pieces and the fertilizer. This method will usually insure the best results.

Potatoes require no special cultivation except to be kept free from weeds and to be hilled up with soil as they develop in order to create a ridge in which the potatoes may form without being exposed to the light. Usually about four cultivations and as many hand hoeings are required. The work can be done entirely with the hoe, or where a horse is available a one-horse cultivator should be used.

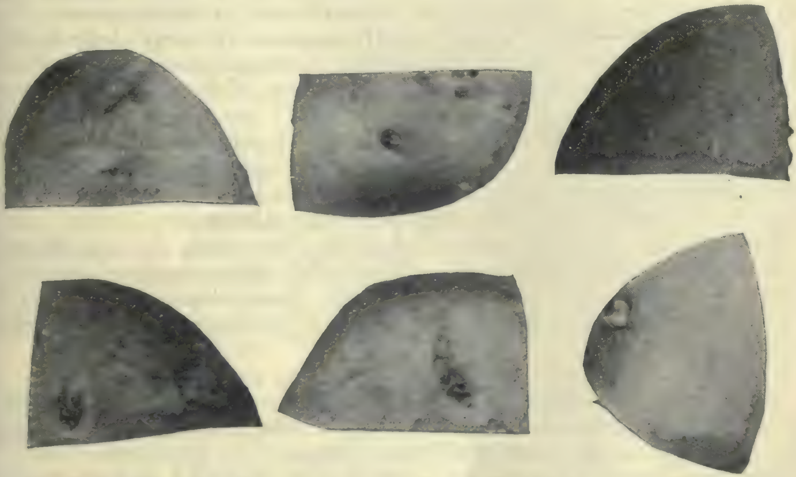

FIGURE 6.—Potato seed cut into chunky rather than thin wedge-shaped pieces.

Early potatoes may be dug about the time that the vines die or shortly afterward. Some of the potatoes may be dug for use while the vines are still fairly green, and in no case should the potatoes be left in the ground more than a week or 10 days after the vines are completely dead. When the potatoes are dug they should be exposed to the sun and wind for not more than 1 hour, and should then be stored in a cool, well-ventilated cellar or in an open shed where they will be cool but protected from the light. If stored in too large quantities or where they will not get air, the early potatoes are likely to rot.

Green Mountain, Russet Rurals, Jersey Red Skins, Irish Cobbler, and several other varieties are used for the main or late crop which produces the winter supply. These are grown in the same manner as early potatoes and as a rule are not dug until after frost has killed the vines. The late crop should be stored in cellars or some place where they can be kept at a temperature between 45° and 50° F.

POTATO DISEASES

Scab.—Common scab is due to a disease organism that lives in the soil; it produces rough-pitted spots on the potatoes. The disease remains in the soil from year to year, and is also carried on the potatoes that are used for seed.

Control.—If possible, avoid planting on land that has produced scabby potatoes. Do not use badly scabbed potatoes for seed, and treat all seed potatoes just before cutting in a solution of formaldehyde or of mercuric chloride. Soak the seed 2 hours in formaldehyde solution (1 ounce in 2 gallons of water) or for 30 minutes in a solution of mercuric chloride made by dissolving the little coffin-shaped tablets at the rate of 1 to each pint of water. *The mercuric chloride should be used only in wooden or stoneware vessels. It is a deadly poison and must be kept away from children and all animals.* Both the formaldehyde and mercuric chloride can be purchased at drug stores.

Early blight.—Early blight usually appears in early July in the Northern States, causing dark, roundish to irregular spots with characteristic target-board markings on the leaves. Moist warm weather is most favorable for its development.

Control.—Spray the plants with a 4–6–50 bordeaux mixture, beginning when the disease is first seen. Repeat spraying every 10 to 14 days in dry weather, and every 7 to 10 days in moist weather. See page 11 for method of preparing bordeaux mixture.

Late blight.—Under weather conditions favorable for late blight, it appears in midsummer on the leaves and stems, causing irregular dead areas. In moist, cool weather the disease spreads very fast, killing the plants in a few days. Later it produces a brown rotting of the potatoes.

Control.—Spray with bordeaux mixture, as for early blight.

Virus diseases.—The so-called "running out" of potatoes is due mainly to the presence of virus diseases, which weaken and dwarf the plants, causing greatly reduced yields.

Control.—These diseases are carried with the seed and cannot be controlled by any form of seed treatment. The planting of seed potatoes that have been grown under inspection and that are sold under a State certification tag is the gardener's only safeguard against loss from virus diseases. It may be possible to secure seed potatoes that have not been grown under inspection and yet are reasonably free from virus diseases, but the use of seed that is certified by some official agency in the State where they are grown is the safest course to follow.

INSECTS AFFECTING POTATOES

The most important insects that injure potato leaves and stems are Colorado potato beetles, leaf hoppers, flea beetles, and aphids (plant lice). The spray materials suggested in the following paragraphs to control the different pests can be combined to give an all-around spray. For the best results against leaf hoppers, bordeaux mixture should be applied about every 10 days from the time the plants are 6 inches high until harvest. When potato beetles or flea beetles are present, add a stomach poison; when aphids are present, add nicotine.

Colorado potato beetles.—The yellow and black striped Colorado potato beetles and their ugly brick-red slugs are known to every grower of potatoes, and are usually referred to as "potato bugs" (fig. 7).

Control.—The gardener with only a few potatoes can prevent serious injury from potato beetles by hand-picking or brushing off and killing the beetles. By examining the under side of the leaves the clusters of orange-colored eggs can be located and crushed. The hand-picking should be repeated at least twice a week. Fortunately, the greedy feeding of this insect makes it easy to control with an arsenical spray or dust. All portions of the plants should be covered with the poison. Either the paris green or the calcium arsenate formulas, when thoroughly and properly mixed, will give satisfactory results.

See page 10 for instructions on how to prepare spray and dust mixtures containing paris green.

Aphids.—Aphids are the tiny greenish- or pinkish-colored plant lice found clustered on the terminal shoots or on the under side of the leaves. These insects feed by sucking the plant juices and, when abundant enough, cause the leaves to curl, often enclosing the lice.

Control.—In order to control these insects it is necessary to apply a contact insecticide, such as nicotine, when the air is still and the temperature high. Either the spray or the dust formula may be used.

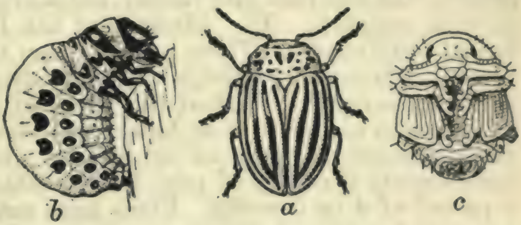

FIGURE 7.—Colorado potato beetle: *a*, Beetle; *b*, larva or "slug"; *c*, pupa. (Chittenden.)

Leafhoppers.—Leafhoppers are minute, active, greenish or yellowish insects. The adults possess wings and, upon being disturbed, fly readily for short distances. The immature forms (called nymphs) when disturbed do not fly but scuttle rapidly over the surfaces of the leaves with a sidewise, crablike motion. Both adults and nymphs rest and feed mostly on the under surfaces of the leaves and thus escape notice, even though they may be present in large numbers. These tiny insects collect in potato fields during hot, dry seasons and produce hopperburn or tip blight. Hopperburn of potatoes appears as brown, and later as blackened, areas at the tips and borders of the leaves. This injury seriously interferes with the crop of tubers.

Control.—The most satisfactory remedy is a thorough application of bordeaux mixture, made according to the formula given on page 11.

Flea beetles.—Flea beetles, as the name implies, are small, dark-colored beetles which, when disturbed, jump away in a manner similar to that of a flea. They injure plants by gnawing small holes through the leaves, which often appear as though fine shot had been fired through them. The beetles usually feed from the under side of the leaves, which should be taken into account when sprays are applied.

Control.—The combination spray of bordeaux mixture and a poison, referred to in the first paragraph under potato insects, will give satisfactory control. Calcium arsenate dust or bordeaux mixture, used alone, will give some relief if applied when the beetles first appear and if repeated in about a week.

PEAS

Peas may be planted just as early in the spring as the ground can be worked. The rows should be 30 inches to 3 feet apart. A pint of seed peas will plant 100 feet of row. On light and sandy loam soils the seed peas should be covered about 2 inches deep; on clay and heavy soils 1 to 1½ inches is sufficient. There are several varieties of dwarf peas such as Little Marvel and Laxtonian which do not require supports. The Thomas Laxton and the Gradus are two of the standard varieties which grow 18 inches to 2 feet in height; the old-fashioned Telephone, which grows 3 to 5 feet in height, is an excellent late variety, but it must be provided with brush or wire supports. The Alaska and the Improved Alaska are extremely early sorts. These are what are termed smooth peas, that is, the seeds are not wrinkled. The quality of the smooth varieties is not quite equal to that of the wrinkled sorts. Peas that are left on the vines to ripen can be hulled and saved for seed. By planting three different varieties or by making successive plantings of the same variety a supply of peas for the table can be maintained over a period of 4 or 5 weeks. Fresh peas not required for immediate use may be canned, but peas are one of the most difficult of all vegetables to can.

PEA DISEASES

Pod spot.—Dark spots sometimes appear on the pods of peas. This trouble, called pod spot, is caused by an organism that also produces spots on the leaves and on the seed, in which it is carried from one season to the next.

Control.—There is no treatment for a diseased crop. The disease can be partially prevented by planting disease-free seed. The vines of a diseased crop should be gathered and burned.

INSECTS AFFECTING PEAS

Pea aphids.—Pea vines having made a good start are often checked and gradually wither, turn yellow, and in some cases shed their leaves. If the plants are shaken, small green aphids, no larger than the head of a common pin, fall to the ground. Upon closer examination the terminal shoots and leaves may be found crowded with either winged or wingless forms of these plant lice.

Control.—Nicotine dust or spray (p. 11) gives the most satisfactory control. The aphids can be beaten from the vines onto the ground by means of a brush of small twigs or a pine bough with the leaves left on. If the brushing is done on a hot, sunny day, when the weather is hot many are killed by the heat of the ground, and few, if any, ever return to the plants.

Seed-corn maggot.—See discussion under bean insects, page 31.

Cutworms.—See discussion under cabbage insects, page 22.

ONIONS

Onions may be planted just as early as the ground can be worked; in fact, in many sections onions may be put in the ground during the fall and given slight protection during the winter. This is especially true of the multiplier or bunch onions. Standard varieties of onions like Prizetaker, Yellowglobe, Red Weathersfield, and Japanese may be grown from seed, from small southern-grown plants, or from the little onion sets which are sold in the stores. One to two quarts of onion sets will be needed to supply the onions required by the average family during the early part of the season. They should be planted in rows 18 inches apart with the sets 2 to 3 inches apart in the rows. The little sets should be placed right side up in a shallow furrow and covered with about 1 inch of soil. Onions are grown almost entirely by hand cultivation. When the onions approach maturity the soil should not be drawn around them; their ripening may be hastened by rolling an empty barrel over the row, or by breaking down the tops with the back of a hoe. This causes the onions to ripen uniformly, after which they may be pulled, dried, the tops removed, and the bulbs stored in a cool dry place. Onions require a very rich soil, and in addition to plenty of fertilizer being used before the plants or sets are planted, they should have at least one side dressing of fertilizer during the growing period. Where onions are grown from seed, the seed is drilled thinly in the rows and covered about 1 inch; then when the plants are about 2 inches high, they are thinned so as to stand 1½ inches apart. Sets are used for planting most of the onions grown in home gardens, but seed is used very largely for starting the commercial crop.

ONION DISEASES

Smut.—Onion smut is caused by a disease organism that lives in the soil where smutted onions have grown. It produces blisters full of black powder on the leaves of young plants, killing them.

Control.—Where onions are grown from seed, sprinkle formaldehyde solution (1 teaspoonful to 1 quart of water) in the drill after the seed has been dropped, before covering them, using 3 to 4 quarts of the solution in each 100 feet of row.

Mildew.—Onion mildew may be noticed on the leaves on a dewy morning when a violet, furry covering may be seen on the surface. The leaves turn pale green and finally yellowish, and the diseased portions of the plants eventually collapse. The disease commonly starts in spots and spreads to surrounding areas.

Control.—Onion mildew usually appears in midseason and may be held in check by thorough cultivation and by spraying the foliage thoroughly with a 4–6–50 bordeaux mixture to which 3 pounds of rosin-fish-oil soap has been added as a sticker. (For full instructions for making bordeaux mixture see p. 11.)

INSECTS ATTACKING ONIONS

The most common insect pests of onions are maggots and thrips.

Onion maggot.—The onion maggot is a small white maggot that bores through the underground portion of the onion, causing the plants to become flabby and turn yellow.

Control.—There is no control after the maggot has entered the bulb, but in gardens where onions are subject to injury, the young maggots can be killed before they enter the onions by pouring a bichloride of mercury solution, as suggested for the cabbage maggot (p. 23), along the row. Make the first application when the onions are about 1½ inches high, and repeat in about 5 days.

Thrips.—Thrips are tiny, elongated insects that feed underneath the leaf sheaths and produce mottled leaves.

Control.—Nicotine-soap spray as described on page 11 is suggested to control this pest.

LETTUCE

Lettuce is what most gardeners term a cool-weather crop, that is, it can be planted early in the spring while the weather is still fairly cool, and must be brought to maturity and used before hot weather sets in. This is especially true of head lettuce, and about the only way to grow good head lettuce in many sections is to start the plants in a hotbed or coldframe and transplant them to the open ground about as early in the spring as the soil can be worked. Good head lettuce of the Iceberg type can be grown almost anywhere if the plants are started early enough so that the heads will form before hot weather. The type of soil is not very important so long as it is rich and contains plenty of organic matter to hold moisture; in fact, almost any good garden soil will grow lettuce if it is properly enriched. Composted manure and commercial fertilizers may both be used to advantage. Lettuce plants grown indoors and transplanted should never be set in a furrow but always on a slight ridge or bed where they will get excellent drainage. Under no circumstances should the soil be hilled up around the lettuce plants. The plants of the larger varieties of head lettuce should be set in rows 15 to 18 inches apart and a foot apart in the row. When the seed is planted directly in the rows where the plants are to grow they should be thinned so as to stand at least 9 or 10 inches apart.

The main heading varieties that are grown in home gardens are New York (which is sold on the market under the name of Iceberg), Improved Big Boston (sometimes called "Unrivaled"), Mignonette (which is a small heading variety), and Hanson, another good heading variety. Certain varieties of nonheading or loose-leaf lettuce, such as Early Curled Simpson, Black Seeded Simpson, and Grand Rapids, will stand the heat of early summer somewhat better than the heading varieties, and so where plants of the heading varieties are planted for the early crop of lettuce, it is good practice to follow up with the planting of one of the loose-leaved sorts for later use.

Occasional side dressings of nitrate of soda or some other highly nitrogenous fertilizer will often aid very materially in hastening the development of the lettuce plants. Too liberal use of nitrogen, however, will cause the lettuce to be dark green in color, tough, and of a bitter flavor. Where the lettuce is watered during the growing period the water should be applied around the roots and not sprinkled over the top. Lettuce requires plenty of moisture, but on the other hand it will not grow on wet soil or on soil that is sour.

Two plantings of 50 plants each as a rule will be all that can be used by the average family during the time that lettuce is at its prime. If the seed is sown in the rows where the crop is to grow, the thinnings can often be used for the table and the plants that remain will develop large bunches or heads, depending upon the variety. A fall crop of lettuce can very often be grown, but the greatest demand for lettuce as a salad crop is in the spring.

LETTUCE DISEASES

Drop.—Lettuce is subject to attack by 2 or 3 diseases, including lettuce drop, which is caused by a fungus that attacks the lettuce plants near the base and causes them to wilt and later to become slimy and drop to the ground.

Control.—The remedy for this disease is to plant the lettuce on ground where the disease has not made its appearance. Where the drop disease occurs, the pouring of a weak solution of formaldehyde on the spot where the affected heads are removed will sometimes kill the hard spore masses that remain in the soil to perpetuate the disease.

Rot.—Head lettuce that is approaching maturity is especially subject to a rot that attacks the lower portion of the heads.

Control.—This trouble can be largely avoided by careful watering and by keeping the soil pulled away from the lower portions of the heads.

Tipburn.—Tipburn is what is commonly called a physiological disease and results mostly from high temperature after the heads are formed. It consists of a burning of the edges of the leaves and frequently extends throughout the entire head, causing its complete loss.

Control.—The maturing of the heads and their use before hot weather is about the only way to avoid tipburning. The use of chemicals in the form of sprays and dusts is of little value in the control of lettuce diseases.

INSECTS AFFECTING LETTUCE

Lettuce is attacked principally by springtails, cutworms, and aphids.

Springtails.—The name " springtail " is derived from the fact that these insects possess a springlike abdominal appendage that projects forward along the underside of the body. When disturbed, the insect extends this appendage, which enables it to jump. The springtails feed on decaying vegetation and seedling plants. They require a certain degree of moisture in order to thrive.

Control.—Dusting the affected area with hydrated lime will prevent damage.

Cutworms.—See discussion on cutworms under Cabbage, page 23.

Aphids.—Aphids or plant lice very frequently attack lettuce plants that are grown in the house or coldframe. These insects may be controlled by dusting the plants with nicotine dust. For preparation of nicotine dust see page 11.

RADISHES

Radishes can be planted early; they grow quickly and constitute a very appetizing fresh food early in the season when such foods are rather scarce. Twenty-five or thirty feet of row will be enough for the average family. The little Scarlet Globe variety, also the variety known as French Breakfast, has been known to be ready for use in less than 20 days after planting. White Icicle, Lady Finger, White Strasburg, Long Scarlet Short Top, and Cincinnati Market are some of the leading varieties of second-early or summer radishes. One packet each of 2 or 3 varieties may be planted at about the same time, but they will come to maturity at intervals and will provide fresh radishes over a period of 4 or 5 weeks.

Radishes require a fairly rich soil. They should be planted in rows 18 inches apart, and the plants should be thinned to stand at least 1½ or 2 inches apart in the rows. The seed should be covered about three-fourths of an inch deep in loam soils, but not more than one-half inch deep in clay soils. Very little cultivation is required because the season of growth is so short. They are soon gone, and some later crop can be planted after them.

In order to save seed of radishes, select a few of the best and simply leave them in the ground to mature and go to seed. When the seed pods are beginning to turn brown, the entire top can be cut off and spread on a sheet to dry, after which the seeds can be beaten out of the pods with a stick, and then cleaned and stored for planting the next year.

RADISH DISEASES AND PESTS

Radishes, as grown in the home garden, are not seriously affected by either diseases or insect pests.

CABBAGE

Cabbage is native to the cooler sections of Europe. It thrives best during the winter and early spring in the South and during the cool portions of the summer in the northern part of the country. There are very distinct early, medium, and late varieties of cabbage. Those of the Jersey Wakefield and Charleston Wakefield type, which have rather small pointed heads, are considered best for early planting, and 25 to 50 plants will produce all of the early cabbage that can be consumed by the average family during the early part of the season. For fall and winter use 100 to 200 plants of a good late variety such as Late Flat Dutch, All Seasons, or Danish Ballhead should be planted. On soils where the cabbage yellows disease is present, one of the resistant strains, such as Wisconsin Hollander, should be planted for the late crop.

The plants for the early crop must be started indoors, or southern-grown plants may be purchased. The plants for the late crop can be grown out-of-doors, as it is not necessary to set them in the garden before the middle of June, or the first of July in many sections. If the cabbage is planted too early the heads will form in advance of cool fall weather, and they will burst and be a loss. The ideal way is to time the planting of the late cabbage so that the heads will reach their maximum size and solid texture about the time that the first heavy frosts or light freezing weather occur in the fall. This will give the best crop of cabbage for storage. Cabbage requires a very rich soil, also one that does not dry out rapidly but is well drained and easily worked. In planting the early crop when the soil is likely to be a trifle wet, it is a good idea to place the plants on slight ridges, the rows being 30 to 36 inches apart and the plants 12 to 15 inches apart in the rows. For the late crop the rows should be 36 to 42 inches apart and the plants set 18 inches apart in the rows.

Side dressings of highly nitrogenous fertilizers will greatly stimulate the growth of the cabbage; the use of too much nitrogen, however, will produce either solid heads that will burst before they can be used or loosely grown heads that are not especially desirable for storing. In setting cabbage plants it is always desirable to pour a little water around the roots of each plant as it is being set, to insure the plants taking hold and getting a quick start. Cabbage is one of the easiest of the garden vegetables to grow as it requires only 2 or 3 cultivations and 1 or 2 hand hoeings. It is also one of the most desirable of the garden vegetables from the standpoint of vitamin and mineral-salt content.

Cabbage may be stored in cool cellars or buried out-of-doors. Slight freezing in the pit does not materially damage the heads; however, if the freezing is too severe it will cause the cabbage to soften and rot.

In many sections a crop of late cabbage can be grown on the same ground where early peas, spinach, or lettuce have been produced. In other localities late cabbage is planted between the rows of early potatoes.

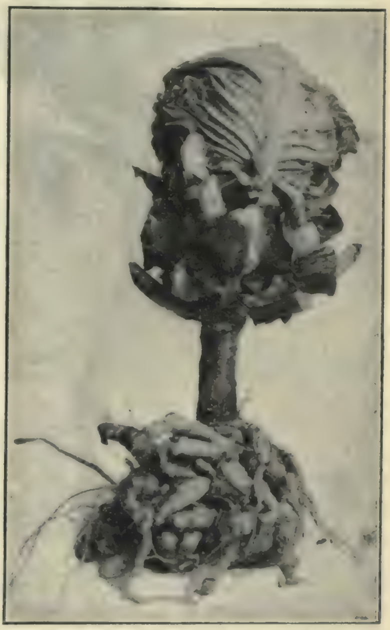
FIGURE 8.—Cabbage plant with large knotted roots caused by clubroot.

CABBAGE DISEASES

Clubroot.—Clubroot of cabbage causes large irregular swellings on the roots, as shown in figure 8. Diseased plants are stunted, have a sickly yellow appearance, and often wilt during the heat of the day. The trouble may attack the plants in the seedbed, or after they are set out.

Control.—Avoid planting any of the cabbage family on land where clubroot has occurred in any of several previous years. If rotation is not possible, apply lime, preferably hydrated, at the rate of 25 pounds per square rod, working it into the soil several months before planting. See that only healthy plants are planted.

Yellows or wilt.—Cabbage plants attacked by yellows are stunted, turn a yellowish green, and the lower leaves fall off. Often one-sided plants are found, or one side of the leaf may be yellow and the other side green. Figure 9 shows a cabbage plant that is affected by the yellows disease.

Control.—Practice crop rotation when possible. The surest means of control consists in the use of seed of yellows-resistant varieties, several of which are now handled by a number of seedsmen. The yellows-resistant Wisconsin Hollander is a late cabbage; while Wisconsin All Seasons and Wisconsin Brunswick are flat types, somewhat earlier and especially suitable for making sauerkraut. Resistant midseason strains, Marion Market, Globe, All Head Select, and an early strain, Jersey Queen, are now available from a few seedsmen.

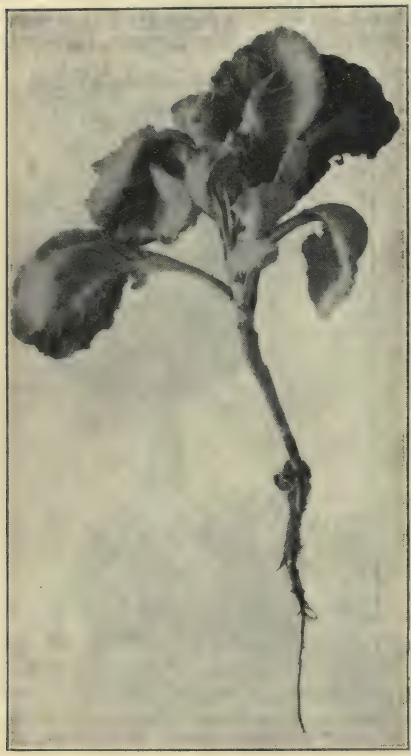

FIGURE 9.—Cabbage plant stunted and leaves curled by yellows.

Black rot.—Plants attacked by black rot usually have yellowed leaves with areas on the edges showing blackened veins, and the insides of the stems show a black ring. Diseased heads often rot in the field or in storage

Control.—Pull and burn affected plants as soon as they are noticed. A long rotation in which neither cabbage nor related plants are allowed to grow on infested land is very important. Disinfect seed in mercuric chloride (see scab of potatoes) 30 minutes, then rinse in clear water. Plant in seedbed soil known to be free of black rot.

Blackleg.—Blackleg attacks cabbage plants while they are very small, often in the seedbed. Blackleg is caused by an organism that produces a blackening and rotting of the stem at about the soil line and on the leaves dark spots in which tiny black pimples appear. The leaves often turn purple; later the whole plant wilts so the tips of the leaves rest on the ground. The disease is carried on the seed, and may be spread by water spattering on the leaves during sprinkling or during rainstorms.

Control.—Disinfect seed as for black rot. Pull and burn diseased plants as soon as seen. Water cautiously to avoid wetting the leaves.

INSECTS AFFECTING CABBAGE

The principal cabbage pests are cabbage worms, aphids, the cabbage maggot, and cutworms.

Cabbage worms.—There are several kinds of caterpillars that often feed on cabbage and related plants. The common cabbage worm is about 1¼ inches long when full grown and of a velvety green appearance. It is the young of the white butterfly which has black spots on its wings. When abundant, these worms feed so heavily upon the heads of cabbage, cauliflower, and other leafy vegetables that the infested plants are stunted and some of them are rendered unfit for food. The cabbage looper is similar in size and habits to the common cabbage worm just described. The larva of the diamond-back moth is another important cabbage pest; this worm is much smaller than the other two.

Control.—Paris green or calcium arsenate sprays or dusts (see formula, p. 10), may be used on cabbage until the heads begin to form, but, because of a poisonous residue, must not be applied too near harvest. After the heads begin to form, other materials should be used for control. Satisfactory results have been obtained by using derris dust containing from three-fourths to 1 percent of rotenone. Pyrethrum dusts and extracts are also effective.

Aphids.—Cabbage plants in seedbeds and at later stages of their growth are sometimes covered with clusters of whitish-green plant lice, about the size of small birdshot. These aphids suck the sap from the leaves, and such affected leaves curl and crinkle or form cups, completely lined with the aphids. If the injury is severe, the plants wilt and die. If the plants are not killed by the aphids they are often dwarfed, grow slowly, and form small, light heads.

Control.—The most satisfactory method of combating this pest is by spraying with nicotine and soap solution or dusting with nicotine dust (p. 11).

Cabbage maggot.—Frequently cabbage plants in the plant bed or in the garden apparently stop growing, and the leaves change to a bluish-green color. If one of these plants is pulled, the rootstocks will be full of mines in which a small white maggot may be found. This maggot comes from a small fly which lays its eggs on the stem at the soil line.

Control.—If a small tar-paper disk is slit from one side, laid flat on the ground, and fitted snugly around the plant at the time the plant is set in the garden, egg laying will be prevented. There is no satisfactory control after the maggots have entered the rootstocks, but one-half cup of bichloride of mercury solution (1 to 1,000) poured around each plant will kill the newly hatched larvae. Make the first application about 4 days after setting the plants and repeat in 10 days. Coffin-shaped tablets containing 7.3 grains of bichloride of mercury can be purchased at drug stores, and one tablet dissolved in a pint of water gives a 1 to 1,000 solution. One ounce of bichloride of mercury dissolved in 7½ gallons of water also gives the desired strength. Bichloride of mercury is extremely poisonous and must be handled carefully. It also corrodes or attacks most metals so should be dissolved and handled in earthen or glass containers.

Cutworms.—There is perhaps no other group of insects so generally destructive to garden crops as cutworms. Their habit of cutting off young plants at or near the soil surface at night and hiding under the soil at or near the base of the plant by day is well known.

Although there are many different kinds of cutworms, varying greatly in appearance and life habits, the following life cycle is fairly typical of the entire cutworm group injurious to garden crops: The adults are dull-brown night-flying moths or millers that are frequently attracted to lights during the summer months. The moths are seldom seen during the day. The eggs are deposited on vegetation or in the soil of weedy or sodded areas during the late summer. The tiny cutworms hatching from the eggs a few days later feed on vegetation until cold weather, when they burrow deep into the soil to pass the winter. In the spring the partially mature worms come to the surface with a greedy appetite brought about by the all-winter fast and are ready to destroy the first succulent garden plants to appear in the spring. The worms complete their growth by early summer, burrow several inches in the soil, and change to moths. Some cutworms vary considerably from this life cycle.

Control.—(1) Since the moths select weedy or sodded areas for egg laying in late summer, gardens kept cleanly cultivated during the egg-laying season are less likely to attract the moths. (2) Fall and winter spading or plowing, where practicable, will turn many of the immature worms up to the attack of weather and other natural enemies. (3) In small gardens cutworms can usually be collected and killed at the base of the plant they have cut down. (4) The surest method of protecting plants from cutworm attack is to use poison bran mash, made as described on page 10.

Where a comparatively small number of cabbage plants are being set in the home garden they may be protected from cutworms by placing a band of rather stiff paper or very light cardboard completely around the stem of each plant. These bands should fit rather closely around the stems and extend 1 inch below the ground and about 2 inches above ground. By cutting the paper in 3-inch squares and rolling around a lead pencil it is easy to place the bands around the stems of the cabbage plants as they are being set in the ground.

KALE

Kale belongs to the cabbage group and requires practically the same soil and cultural conditions as cabbage. In all of the warmer sections of the country kale can be planted on the top of the ridges in the fall of the year and will remain in the open ground all winter, producing a crop during the late winter or early spring.

The usual practice is to throw up ridges about 6 or 8 inches in height and 3 feet apart; after leveling the ridges a trifle place a little pinch of seed at intervals of 12 or 14 inches along the tops of the ridges. Later, when the plants appear, they may be thinned to 1 or 2 in a place. For spring planting the rows should be made about 3 feet apart and nearly level. The seed can be sown thinly in a drill and the plants thinned. The curled Siberian is one of the most common and best varieties. Kale will not stand any great amount of heat and is at its best when grown as a late fall or early spring vegetable.

KALE DISEASES

Control.—Same as for cabbage diseases.

INSECTS AFFECTING KALE

The only pest of kale that is economically important is the turnip aphid. This pest has already been discussed under Cabbage.

SPINACH

Spinach is perhaps the most important of the spring and late-fall greens, although in northern sections it can be grown during the entire summer and in southern sections throughout the winter. In the intermediate sections spinach can be planted as early in the spring as the ground can be conveniently worked, and also late in the summer for a fall crop. Spinach will be ready for use in 6 to 10 weeks after it is planted. In the southern sections spinach can be sown during October and November and will be available for use the entire winter. The usual method is to throw up beds about 5 or 6 feet in width and plant 5 to 7 rows of spinach on each bed, or in some cases the seed is sown broadcast on the beds. For spring planting and where bedding is not essential for drainage, spinach can be planted on level ground in rows usually spaced from 9 to 12 inches apart; about 15 seeds are sown to the foot. As a rule this will be a little too thick for the plants to grow, but the earliest plants can be thinned out and used, thus making more room for the rest.

Spinach will not thrive well on extremely sour soil, and where the soil is sour lime should be used moderately, about 3 pounds on each 100 square feet of surface. For spring planting use the variety known as Longstanding or Bloomsdale Savoy; for fall planting use the Norfolk Savoy, which is a blight-resistant variety that stands the winters better than the common Savoy.

The secret of having plenty of spinach for use is to make several seedings beginning just as early as possible in the spring, plant every 2 weeks until midsummer, and then make several fall plantings beginning about the first of September. In the extreme northern part of the country the plantings can be made at intervals of about every 30 days throughout the spring and summer.

SPINACH DISEASES

Blight.—Spinach blight appears first as a mottling of the young inner leaves. They later change to a yellow color and are finally killed. The disease gradually spreads to the outer leaves, which in turn are changed to yellow. As the disease progresses and before there is any killing, the leaves curl and wrinkle.

Control.—Plant seed of the Norfolk Savoy variety, which resists the disease. Maintain vigorous plants by thorough cultivation and give a liberal application of fertilizers. Plant on well-drained soil.

INSECTS AFFECTING SPINACH

Spinach aphid.—The principal insect pest of spinach is the spinach aphid. The young aphids are pale yellowish green with three dark lines on the back of the abdomen.

Control.—The control measures for this aphid are the same as for the other aphids already discussed, that is, spraying or dusting with a strong contact insecticide such as that recommended for aphids on cabbage.

CARROTS

The carrot is considered one of the best of the early vegetables from the standpoint of its food and vitamin value. The seed can be planted as soon as the ground becomes slightly warm. The rows should be spaced about 18 inches apart and 30 to 40 seeds planted to each foot of row. The seeds should be covered not more than half an inch in light loamy soils and a trifle less in the heavy clay soils. After the plants are up they must be thinned to 6 or 8 to a foot, but it is necessary to have a much larger number of plants to begin with, in order that the little seedlings may push through the surface. It is very important that the plants should be thinned just as soon as they are large enough to handle.

Carrots require a deep, rich, loose soil containing an abundance of organic matter so as to hold a reasonable amount of moisture. The crop requires frequent hoeing and hand weeding, in order to keep the rows free of grass and other weeds that have a tendency to smother them. It is good practice to make two plantings during the early part of the season, about 4 weeks apart, as the second or later planting usually produces a better grade of carrots for storage purposes.

The variety known as Chantenay is perhaps the most universally grown, although there are a number of excellent varieties, such as Early Rubicon, Danvers Half Long, and Coreless. The fresh carrots can be used direct from the garden during the entire summer; then in the fall as cold weather approaches all that remain may be pulled and stored in an outdoor pit or packed in moist sand in a cool cellar. Before the carrots are stored the tops should be cut off about half an inch above the roots.

CARROT DISEASES

Carrots, as grown in the home garden, are remarkably free from diseases, and where the plants are properly thinned and cultivated attention need rarely be paid to carrot diseases.

INSECTS AFFECTING CARROTS

Carrots are comparatively free from insect pests, and in ordinary gardens they do not require protection from insects. The foliage of carrots is sometimes damaged by a rather large, highly colored green and yellow worm, but hand picking these worms when they appear is usually effective.

BEETS

The beet is another of the garden vegetables or root crops that is of high food value, and may be planted in rows 18 inches apart, or about the same as for carrots. Beets require a rich, well-drained soil; however, they do not go as deeply into the soil as carrots and several other of the root crops. About 1 ounce of seed will be an abundance for the home garden, and this should be planted rather sparingly as each of the seed balls may contain 2 or 3 individual seeds. For that reason about 8 or 10 of the seed balls are planted in each foot of row; 100 feet of row will usually provide enough beets for the average family. The seeds should be covered about half an inch deep on light soils and a trifle less on heavy soils. The plants should be thinned to stand at least 3 inches apart, although they can be left somewhat irregular in the row and in that way about 6 plants can be left to the foot of row. The young tender thinnings make excellent greens. Crosby's Egyptian, Detroit Dark Red, and Eclipse are among the leading varieties for planting in the home garden. Some gardeners follow the practice of making two plantings as with carrots. This provides an extra supply for late summer and for storage.

DISEASES OF BEETS

Garden beets are often injured by cercospora leaf-spot disease which consists of numerous small round or irregular dead spots with white centers and purple borders appearing on the leaves. They are caused by a fungus that attacks both beets and Swiss chard, often causing the leaves to curl, dry up, and die. The treatment for this disease is to spray the beets with a 4–6–50 bordeaux mixture when the first spots are observed, and for complete control repeat the spraying every 10 days.

INSECTS AFFECTING BEETS

The principal insect pests of beets are blister beetles and flea beetles.

Blister beetles.—Sometimes beet leaves are stripped, and only the midribs are left. The damage is caused by beetles almost three-quarters of an inch long. These beetles may be black, gray, or striped.

Control.—As the name indicates, blister beetles are irritating to tender skin, and precautions should be taken when hand picking for control is practiced. The beetles can also be killed by being brushed into a pail containing water to which a little kerosene has been added.

Flea beetles.—Flea beetles are tiny, active jumping beetles which eat small circular holes in the leaves.

Control.—The method of control is the same as that for the potato-flea beetle (p. 15).

SWISS CHARD

Swiss chard is similar to the garden beet in its habit of growth, except that it grows almost entirely to tops and does not form an enlarged root. The stems and tender leaves make most excellent summer greens, being cooked exactly as beet or other greens. Swiss chard withstands the heat of summer better than spinach, mustard, and other crops that are usually grown for greens. The variety known as Lucullus is considered the best. The planting and culture are exactly the same as for beets, except that the plants should stand approximately 6 inches apart in the rows. If desired, the seed can be sown in a seedbed and the plants transplanted. If the seed is sown where the plants are to remain, the plants may be thinned and the thinnings used as greens. All but the very hearts of the remaining plants may be cut or pulled frequently for greens and the plants will put on a new growth. Swiss chard is not easily injured by cold and may often be used in the fall after frost. The tender leaves and leaf stems are used for food.

DISEASES OF CHARD

Cercospora or leaf spot is often severe on Swiss chard in some localities. Spraying with bordeaux mixture for its control is impractical because the spray residue makes the leaves unfit for food. Severe cutting back together with cultivating, watering, and fertilizing will usually result in new growth free from the leaf spot.

INSECTS AFFECTING SWISS CHARD

Swiss chard is sometimes attacked by blister beetles. These are easily recognized, as they are long and noticeably slender, with black, gray, or striped bodies. On Swiss chard they can best be controlled by hand picking. Foliage that is damaged by blister beetle should be cut off and discarded and new foliage will form.

PARSNIPS

The parsnip is adapted for growing throughout the northern portion of the United States. Any deep fertile soil will grow parsnips, but it should be spaded or plowed to a depth of at least a foot and enriched with fine well-rotted manure and commercial fertilizer. A shallow, stony, or lumpy soil is inclined to produce rough, prongy roots. Coarse manure should not come in direct contact with the roots for the same reason.

Parsnips should be planted in rows 18 to 24 inches apart, and the seed should not be sown until the ground is fairly warm. Only fresh parsnip seed should be planted, as the seeds are practically worthless if kept over until the second year. Hollow Crown and Guernsey are good varieties. The plants should be thinned to stand about 3 inches apart in the rows. Cultivation methods are the same as those recommended for beets and carrots.

Parsnips may be dug and stored in a cellar in moist sand, or they may be left in the ground until they are used. Roots placed in cold storage gain in quality, and freezing in the ground in the winter also improves the quality.

Parsnips as grown in the subsistence garden are not subject to any serious diseases or attacks by insects.

SALSIFY

Salsify, sometimes called oyster plant, can be grown in practically the same manner as parsnips. The roots may be dug and stored in the cellar, or they may remain in the ground until wanted for use. Salsify has no special disease or insect enemies as grown in the subsistence garden.

BEANS

Beans are among the best foods grown in home gardens. They are divided into 3 or 4 groups; the snap or bunch beans that are used fresh from the garden or are canned for winter use, the dry beans, and lima beans. In addition, there are the so-called black-eyed peas and crowder peas which are used the same as beans.

There are two types of snap beans, the green podded and the wax podded, and each of these is divided into the flat-podded and the round-podded types. Stringless Greenpod is one of the leading round-podded green snap beans. It matures in 50 to 53 days after planting. Recently, a new round-podded bean has appeared under the name of Tendergreen. It is claimed that it will mature in about 53 days after planting. Bountiful, a flat-podded green variety, matures in 48 or 50 days and is a very popular variety for the home garden. Among the wax-podded bush beans, Pencil Pod Wax, which matures in about 52 days, is one of the most desirable for the home garden. Another good wax bean is the Round Pod Kidney Wax. Among the early pole beans which may be used either as green beans or as dry beans Kentucky Wonder, or Old Homestead, as it is sometimes called, stands at the head of the list. In the lima bean group are two classes, the dwarf and the pole. The baby lima or Henderson's Bush is one of the best for southern and central locations, because it stands the heat of summer so well. However, the beans of this variety are quite small, and many people prefer to grow the Fordhook Bush lima, which is sometimes called potato lima and has extra-large plump beans of very fine quality. Among the pole limas the King of the Garden is one of the best. The bush limas as a rule will mature in 75 to 80 days, whereas the pole limas require about 90 days.

Bunch or snap beans should be planted in rows at least 30 inches apart and the hills 15 to 18 inches apart in the rows, with 3 or 4 plants in each hill. The bush lima beans require a little more space than the bunch snap beans; the rows should, as a rule, be 36 inches apart and the hills 18 to 20 inches apart in the rows. For the large-growing pole beans like Kentucky Wonder and the pole lima the hills should be placed about 3 by 4 feet. Three plants of the Kentucky Wonder may be left in the hill to climb on a single pole, but not more than two plants of the large-growing pole lima should be allowed to each pole, and one plant is really better. One method of planting pole lima beans is to place the hills in the form of a triangle, and then fasten the three poles together at the top, Indian-wigwam fashion, and allow one plant to each pole. By this method the poles do not have to be set in the ground more than 5 or 6 inches, but where the poles stand alone they should be set at least 15 inches deep in order that they may stand up with the load of bean vines upon them.

Bunch or snap beans require a fairly rich soil, but the application of too much fertilizer will often cause them to grow excessive tops and put on comparatively few beans. With lima beans, especially the pole lima, there is little danger of getting the soil too rich. Snap beans may be planted about the time that the last spring frosts occur. On light and loamy soils the seeds should be planted about an inch deep, but on heavy clay soils, or where the soil is fairly wet at the time of planting, the seeds should be covered not more than one-half an inch. As a matter of fact, if they are scarcely covered at all they will come up to better advantage. In the case of lima beans it is customary to take each seed between the thumb and finger and thrust it eye downward into the soil, and where the soil is the least dry they should be covered deep enough to reach moisture. In the average home garden it is a good plan to have a few of each kind of beans in order to give variety and maintain a continuous supply. One or two plantings of lima beans will be sufficient, but with the snap beans it is a good plan to make a planting about every 2 or 3 weeks; however, 50 to 60 feet of row will be an abundance for planting at any one time. If soil conditions are right it is easy to get a stand of snap beans. Lima beans are especially susceptible to cold and wet, and for that reason the seeds should not be planted until the ground is warm. Under no conditions should the seeds be put in the ground when it is excessively wet.

BEAN DISEASES

Anthracnose.—Anthracnose may be recognized on the pods by roundish sunken spots, with dark-brown or black borders and pink centers. It also produces elongated sunken, dark-red cankers on the stems and leaf veins, and grows through the pods, causing rusty looking spots on the ripe seed. The organism that causes this disease lives over winter in the seed and attacks the young seedlings. The disease is worst during moist, cool weather.

Control.—As anthracnose does not usually occur on bean seed grown in the States from Colorado west, it is best to buy western-grown seed if possible. Pull up and burn the first plants showing the disease. Do not cultivate, walk through, or pick beans when the vines are wet. To do so will spread the disease and make it worse. Wells Red Kidney, White Imperial, and Perry Marrow, all dry shell-bean types, are resistant to anthracnose and may be grown if dry shell beans are wanted.

Blight.—Bean blight causes irregular diseased areas on the leaves which at first are water-soaked, later become brown and brittle, and usually have pale yellow borders. It attacks the stems, producing reddish cankers. On the pods slightly raised watery pustules appear, which later enlarge and become irregular in shape and rusty in color. The disease is carried in the seed.

Control.—The same as for anthracnose. A few varieties of garden bush beans are somewhat resistant to the disease: Late Stringless Green Refugee, Refugee 1000–1, and Refugee Wax. Procure western-grown seed if possible.

INSECTS ATTACKING BEANS

The principal insect pests attacking beans are the Mexican bean beetle, the bean leaf hopper, the bean aphid, the seed-corn maggot, and the bean weevil.

Mexican bean beetle.—In many localities this insect is the worst pest of beans. The beetles are from one-fourth to one-third inch long, shaped like a split pea, and from yellow to coppery brown in color. On the back are 16 small black spots, forming three rows across the body, as shown in figure 10. In general appearance they resemble the beneficial lady beetles. The young of the beetles are yellow grubs with rows of branched spines on their backs. When full-grown these grubs are about one-third of an inch long. Both the beetles and larvae eat the bean leaves, and when they are very abundant they feed on the pods and stems.

Control.—In the home garden these insects can be controlled by hand picking provided the practice is started early and repeated often enough. Crushing the yellow egg clusters that may be found on the under side of the leaves will also prevent a brood of larvae. Derris or cubé root sprays or dusts, applied to the under side of the leaves, are now recommended as the most effective control for this pest. In general, spraying is recommended in preference to dusting, but good results may be obtained with the dust mixture when applied properly. These materials can be prepared according to the following formulas, on the basis of derris or cubé root powder containing 4 percent of rotenone:

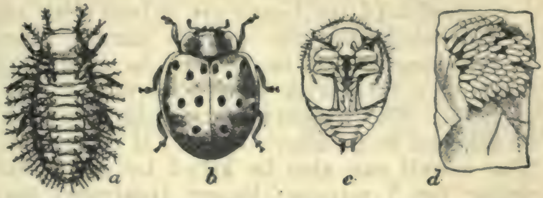

FIGURE 10.—The Mexican bean beetle: *a*, Larva; *b*, beetle; *c*, pupa; *d*, egg mass. About three times natural size.

Spray:	
Derris or cubé root powder	1½ ounces or 1½ pounds
Water	3 gallons or 50 gallons
Dust:	
Derris or cubé root powder	10 ounces or 12½ pounds
Finely ground talc, sulphur, tobacco dust, gypsum, or other inert powder, except lime	4⅜ pounds or 87½ pounds

If the rotenone content of the derris or cubé root powder is greater or less than 4 percent, the quantity of the powder should be varied accordingly when preparing a spray or a dust. When applied at the dilutions mentioned above, the sprays or dusts containing derris or cubé do not leave harmful residue on the harvested beans.

Paris green, calcium arsenate, or lead arsenate should not be used on beans at any time because they will injure the foliage.

Leafhoppers.—These small, greenish-yellow, active insects suck the juice from bean foliage and prevent normal development.

Control.—Same as for leafhoppers on potatoes, page 15.

Aphids.—Occasionally the terminal shoots of beans are covered with tiny black aphids (plant lice). These sap the vitality of the plant and prevent growth.

Control.—With nicotine, as recommended under Potatoes, page 15.

Seed-corn maggot.—Sometimes in wet seasons beans fail to come up or perish just as they come through the ground. If the seed is examined closely, small white maggots will be found causing the damage. The parent flies which lay the eggs that produce these maggots are attracted to decaying vegetation to deposit their eggs, and in wet seasons the maggots are able to crawl about and locate the germinating seed. In wet seasons beans should not be planted immediately after plowing or spading, especially if much vegetation has been turned under.

Control.—If possible, allow the vegetation to decay and the soil to dry before planting the seed. Keep manure out of the seed row. Planting should be shallow.

Bean weevil.—Seed beans or dry beans for table use are sometimes bored full of holes and are unfit for seed or food. This damage begins in the garden, where the parent weevil deposits a tiny egg inside the pod.

After the egg hatches the larva enters the bean and does not change to an adult until the beans are stored. When beans are stored in a warm place the weevils continue to reproduce.

Control.—If the beans are mixed with one-sixth of their weight of hydrated lime the weevils cannot reproduce in storage. The weevils inside the beans can be killed by heating. Spread the beans in a thin layer in a shallow pan and heat in an oven for 30 minutes. The temperature should be above 120° F. but should not be allowed to go above 135° F. if the beans are to be used for seed. The weevil can also be killed by suspending the beans in boiling water for 1 minute; longer treatment may prevent germination. The beans should be spread out and dried quickly after removal from the bath.

SWEET CORN

Sweet corn requires too much space for growing to any extent in the small garden. It is sometimes possible, however, to grow a small block of very early sweet corn, then follow it with late cabbage or with turnips. Where there is sufficient space, about 2 plantings of an early variety should be made, and 2 or possibly 3 plantings of a later variety. Sweet corn should not be planted until the ground is reasonably warm. It requires a rich soil, and the hills should be spaced about 3 by 4 feet, that is, if the rows are 4 feet apart the hills should be 3 feet apart in the rows. For the dwarf varieties like Golden Bantam the hills may be placed 3 by 3 feet with 3 stalks in a hill. The usual custom is to mark off the rows, then drop about 5 grains of the seed corn in each hill, and cover it with 1 to 1½ inches of soil. If more than 3 plants appear in a hill the extra ones are thinned out. Golden Bantam, Golden Cross Bantam, Whipple Early White, Howling Mob, and Mammoth White Cory are among the leading early varieties; Country Gentleman, Stowell Evergreen, and Golden Evergreen are among the leading medium and late varieties.

In planting sweet corn in the garden it should be borne in mind that the corn will not pollinate and the ears will fail to fill unless several rows are planted together; therefore, it is best to plant sweet corn in a block rather than in the form of a few long rows. Where the blocks of sweet corn can be placed side by side the first, second, and subsequent plantings can be located in a continuous section; in that way good results in the pollinating and filling of the ears will be obtained.

Corn requires from 3 to 5 cultivations, mainly to keep the ground free from weeds. Deep stirring of the soil toward the time of the maturity of the ears is not desirable because the roots of corn run near the surface and the deep stirring of the soil will break the feeding roots and check the growth of the corn. For best results sweet corn should be cooked and on the table within 2 hours after being pulled, as it loses in sugar content very rapidly after it is pulled from the stalk. Keeping the corn in a refrigerator at a temperature below 40° F. after it is pulled will largely prevent the loss of sugar.

DISEASES OF SWEET CORN

As a rule sweet corn is not seriously troubled by diseases, but in certain sections there is a disease known as "Stewart's disease." In these sections resistant varieties are being developed and should be planted.

Sweet corn is frequently affected by smut on the ears, in the tassels, and on the stalks. Wherever the smut appears, the affected parts should be removed and burned immediately to reduce the infectious material for the following year.

INSECTS AFFECTING SWEET CORN

There are two important insects that attack sweet corn—the European corn borer and the corn earworm.

European corn borer.—The corn borer is a serious pest in sections of the country where it has become established. There is really very little that the home gardener can do to control the corn borer except to cut and destroy all cornstalks as soon as the ears have been removed. This will prevent the worms that are in the stalks from maturing and to some degree will hold the insect in check.

Corn earworms.—This worm works mainly in the tips of the ears of corn but will sometimes eat its way to the middle or lower part of the ear. The eggs are laid on the young corn silks by a moth that flies at night. Dusting the young corn silks with arsenical poisons may kill some of the worms when they first hatch, but there is no remedy that is fully effective. This insect is also known as the tomato fruitworm (fig. 11).

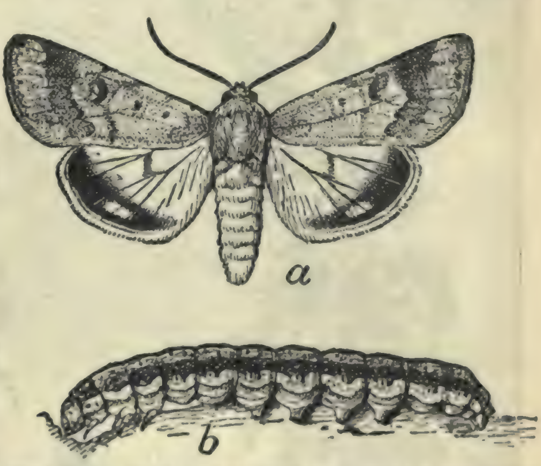

FIGURE 11.—Tomato fruit worm: *a*, Moth; *b*, full-grown fruitworm. (Chittenden.)

TOMATOES

The tomato is a very important garden crop because of its vitamin content when eaten raw and its many desirable qualities when cooked or canned for winter. Plants for early tomatoes should be started indoors, but those for the main or late crop may be started in a coldframe and in some sections in the open ground. For the average garden 25 to 50 early plants will be enough, but 50 to 100 or more late plants should be set to furnish plenty of tomatoes for canning. Two methods are used for growing the early crop. The method where the plants are set about 2 by 3 feet and trained to stakes has much to recommend it, especially where garden space is limited. As the plants are set, after all danger of frost is past, a strong stake about 4 feet in height is driven alongside of each plant. As the plants grow, the side shoots are all removed while still quite small; and the main stem bearing 5 or 6 clusters of fruit is tied to the stake with strips of muslin or soft twine, as shown in figure 12. The other system consists of planting the tomatoes about 3 by 4 feet apart and allowing them to branch freely and to grow naturally on the ground.

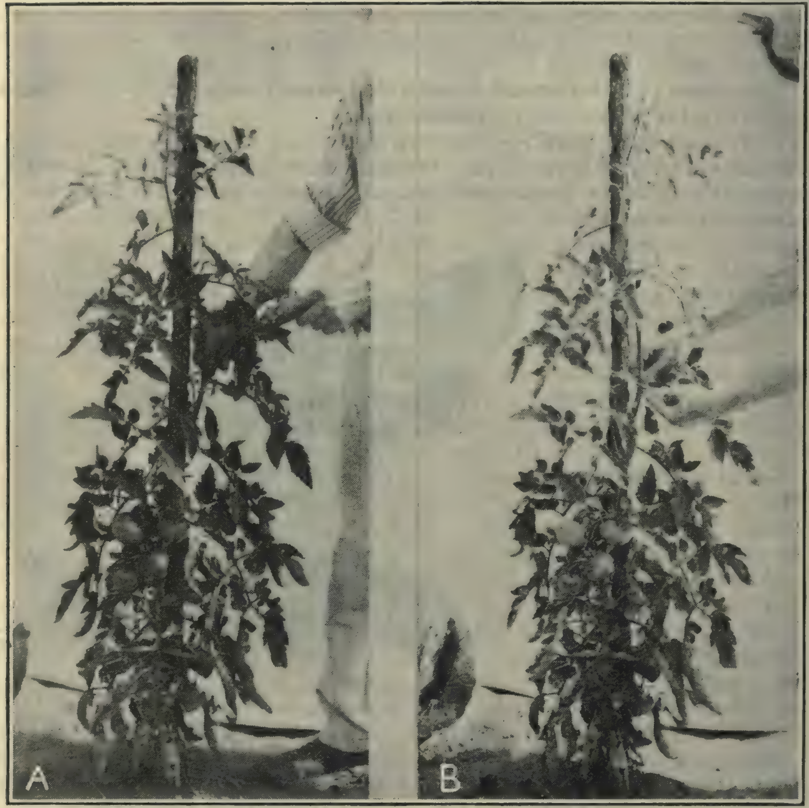

FIGURE 12.—Training tomatoes to stakes: *A*, Cutting out the side shoots or branches; *B*, tying the main stem to the supporting stake.

The late or main crop of tomatoes is usually planted in rows 4 feet apart, with the plants 3 feet apart in the rows, and allowed to grow naturally. The green tomatoes that remain on the vines at the close of the season may often be gathered before they become frosted, and ripened in a room having considerable moisture in the air and a temperature of about 55° or 60° F. Some gardeners follow the practice of pulling the vines with the green tomatoes attached and hanging them in the cellar for the tomatoes to ripen. Bonny Best, Pritchard, Break O'Day, Marglobe, Stone, and Ponderosa are among the varieties most commonly grown in home gardens. The little yellow, pear-shaped tomatoes are often grown for making tomato butter and tomato preserves.

DISEASES OF TOMATOES

Tomatoes are subject to attack by 3 or 4 rather serious diseases, including Septoria or leaf spot, wilt, and blossom-end rot.

Leaf spot.—Leaf spot is caused by a fungus that attacks the leaves and stems, causing small circular spots with light centers and dark margins. It starts on the lower leaves and progresses upward, causing them to curl, dry up, and fall off, leaving the stems bare except at the tips.

Control.—The remedy is to plant only healthy plants and to spray thoroughly with bordeaux mixture, beginning as soon as the plants are set and repeating the treatment every 10 days.

Wilt.—The widespread and serious tomato disease known as wilt is caused by a fungus that lives in the soil and is also carried in the seed. It enters the roots from infested soil, grows into the water vessels, and produces an upward curling of the leaves, followed by gradual yellowing, wilting, and death of the affected plants (fig. 13).

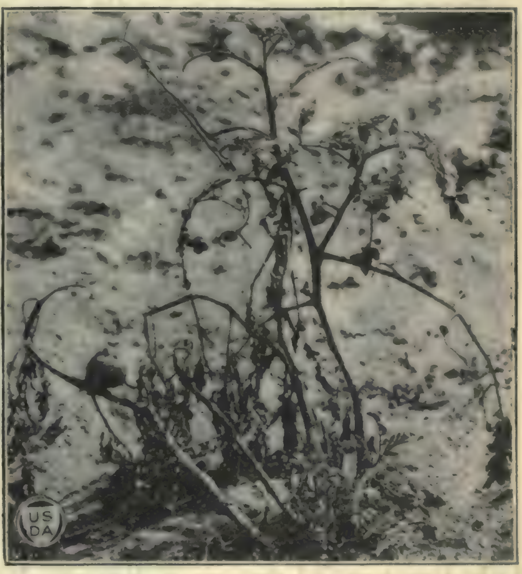

FIGURE 13.—Tomato wilt (late stage), showing dead leaves and stems and unfruitfulness.

Control.—To prevent this disease use clean, new soil for growing the plants; and if the home garden has become infested with wilt, plant only wilt-resistant varieties such as Pritchard, Marvel, and Marglobe.

Blossom-end rot.—This rot, while not clearly understood, is known to cause large, dark, sunken spots on the blossom end of the green fruits.

Control.—The disease seems to be worse during dry weather, and watering and frequent cultivation seem to be the only remedies. Growing the crop on land containing plenty of organic matter to increase the water-holding capacity of the soil seems to help.

INSECTS THAT ATTACK TOMATOES

Tomatoes are attacked by three insects—tomato hornworms, tomato fruit worms, and flea beetles.

Tomato hornworms.—Tomato hornworms are large green worms that feed on both tomato and tobacco plants (fig. 14). There are two kinds of hornworms, both very much alike, and in the moth or adult stage they are known as humming-bird moths. A large hornworm can strip a tomato plant of its foliage in 2 or 3 nights, leaving only the stems.

Control.—Hand picking is the best remedy in the home garden. The worms are about the color of the tomato vines and are very hard to see. Therefore, the vines should be examined carefully each day, after the work of the worms becomes noticeable.

Tomato fruit worm.—The tomato fruit worm, also called the corn ear worm, is the cause of much trouble to tomato growers, as it eats into the ripening fruit and destroys it.

Control.—This insect may be partially controlled by spraying with calcium arsenate or paris green, but it is not safe to spray the fruits after they become half grown. All tomatoes from sprayed vines should be washed or wiped thoroughly before being used.

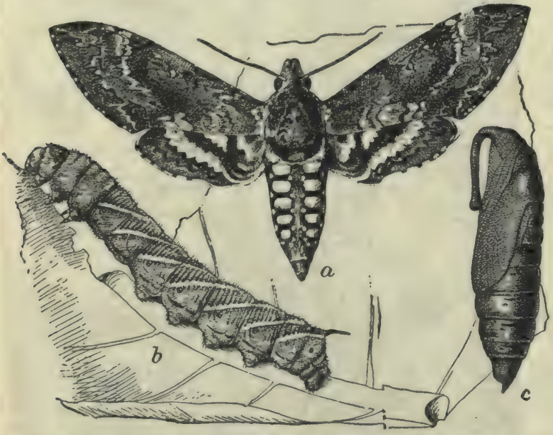

FIGURE 14.—Tomato hornworm: *a*, Moth; *b*, hornworm; *c*, chrysalis. About one-half natural size. (Howard.)

Flea beetles.—The potato flea beetle frequently attacks tomatoes and does much damage. It is especially troublesome on the young plants and is often carried to the garden with the plants.

Control.—Dipping the plants in a solution consisting of 3 ounces of calcium arsenate in 1 gallon of water before setting them out is effective. The thorough spraying of the plants with bordeaux mixture is also effective, as this will drive the beetles away.

PEPPERS

The sweet or bullnose pepper is very popular as a garden vegetable. The seeds should be sown indoors early in the spring, and the plants set in the garden after all danger of frost is past. Peppers require a very rich soil, and if kept well cultivated, watered, and free from weeds the plants will continue to produce until frost. Chinese Giant, Ruby King, World Beater, and California Wonder are among the leading varieties of large sweet pepper. The pimiento is a medium-sized, thick-walled, sweet pepper that is especially fine for preserving and is largely used for making the canned pimientos sold in the stores. There are also numerous varieties of Cayenne or hot peppers that are used for seasoning and for making chili and hot pepper sauces for use on meats and in stews.

DISEASES AND INSECT PESTS

Peppers are subject to a number of diseases, but these are not as a rule serious in the home garden.

Peppers are practically free from insect injury in the home garden, so much so, in fact, that the subsistence gardener will seldom encounter any difficulty in this line.

EGGPLANT

Eggplant is a warm-weather crop, and the plants must be started indoors and planted in the open after the weather has become warm. The plants must be kept growing vigorously from the very start; otherwise they will become tough and woody, and when once they reach that condition they are practically worthless. The plants should be set about 3 feet apart in each direction, and the soil should be very rich and well drained. Black Beauty, Early Long Purple, and New York Spineless are the leading varieties. Eight or ten plants will usually produce all of the large fruits that an average family will consume.

DISEASES OF EGGPLANT

Certain leaf and fruit diseases attack eggplant, especially when the crop is grown on a large scale, but where only a few plants are grown in the home garden there is not likely to be any serious loss from diseases.

Control.—Spraying the plants with bordeaux mixture will very largely prevent the development of diseases.

INSECT ENEMIES

The young plants of eggplant are frequently injured by flea beetles, and the presence of these insects is manifest by the appearance of small round holes in the leaves.

Control.—Spray or dust both sides of the leaves with calcium arsenate. As a spray the calcium arsenate may be used in combination with bordeaux mixture. Bordeaux mixture alone has the effect of driving the insects away. A dust of 1 part of calcium arsenate to 8 parts of hydrated lime may be effectively used. *Be careful about the use af arsenical poisons on the plants after the fruits begin to form.* The common Colorado potato beetle is also troublesome on eggplant, but it may be controlled in the same manner as flea beetles.

SQUASHES AND PUMPKINS

Summer squashes, especially the Summer Crookneck type, should be included in practically every subsistence garden. Winter squashes, especially those of the Boston Marrow and Hubbard types, may often be grown to advantage and stored for winter use. These winter squashes are good for planting in the sections that are too far north for the growing of sweetpotatoes. All kinds of squashes require a rich, well-drained soil, and it is a good idea to work a shovelful of rotted manure and a small handful of commercial fertilizer into each and every hill. The early or summer squashes may be planted in hills 4 to 5 feet apart in each direction, but the winter squashes should be spaced at least 10 feet apart in each direction. About 7 or 8 seeds should be planted in each hill, and after the plants are started they may be thinned to about 3 in a hill.

The early or summer squashes should be gathered and used while the skins are still tender so that they can be punctured with the thumb nail. In the case of the winter squashes they should be allowed to remain on the vines until fully ripened; however, they should be gathered and stored before there is any actual freezing.

The methods of storage are similar to those for sweetpotatoes; that is, they should be placed on shelves or in crates and cured at a temperature between 80° and 85° F. for several days, then be kept at a temperature around 55° or 60°. A shelf in the furnace room of the home is often a good place to store the winter supply of squashes. In handling them when they are to be stored it is important that they be handled carefully and that the skin does not become punctured. They should be gathered with a short piece of the stem attached to them.

Pumpkins may be planted in the corn patch or on ground where early crops have been removed. Their culture is the same as for squashes except that they make a rather long vine growth and need more room.

The Connecticut cheese or pie pumpkin is one of the best varieties for growing in the home garden.

Pumpkins should be stored in exactly the same manner as winter squashes.

DISEASES OF SQUASHES AND PUMPKINS

Squashes and pumpkins are subject to a mildewing of the leaves and certain leaf spot diseases, but none of these prove very serious in the home garden, and for that reason the subsistence gardener need not consider them unless more serious outbreaks than normal should occur.

Control.—Spraying the foliage and stems with bordeaux mixture will often largely prevent the occurrence of any of these diseases.

INSECTS AFFECTING SQUASHES AND PUMPKINS

The striped cucumber beetle very frequently attacks the young seedling squashes and pumpkins just as they emerge from the ground. Dusting the plants with a mixture of 1 part calcium arsenate and 5 or 6 parts hydrated lime is usually effective in controlling these insects. When only a few hills are being grown in the home garden it is often possible to cover the hills with small pieces of cheesecloth until the plants are well established and less liable to attack by the striped cucumber beetle. The cheesecloth should be supported on arches made of wires or barrel hoops set over the plants, the edges of the cheesecloth being weighted down with soil.

Another method is to start the hills of early squashes in quart berry boxes of soil in the hotbed or coldframe. By the time the plants can be set in the open they will be past the stage of most serious attack by the striped cucumber beetle.

Squashes and pumpkins are also attacked by aphids which work on the underside of the leaves. Spraying or dusting the plants with nicotine will control these insects.

Squashes are frequently killed by the squash vine borer which enters the stem at or near the surface of the ground and bores tunnels in the squash vines as shown in figure 15. When the borers attack the squash vines it is almost impossible to kill them without killing the plants. The borers may sometimes be cut out of squash vines by slitting the stems of the vines lengthwise. Afterwards, these portions of the vines should be covered with soil to help the plant grow extra roots.

MELONS

Muskmelons and watermelons are not recommended for growing in subsistence gardens except under the most favorable conditions and where there is plenty of land available without restricting the planting of more important food crops. The culture of muskmelons is practically the same as that for squashes and pumpkins. Muskmelons may be grown on any good garden soil, but watermelons are at their best when grown on a warm, sandy loam. There are a great many varieties of muskmelons, but those of the Netted Gem type are considered best in most localities. Throughout Ohio and Indiana, the variety known as Tip Top is largely grown. In Michigan Hearts of Gold is ordinarily grown. Owing to the uncertainty of producing a good quality of muskmelon in the home garden, subsistence gardeners should go rather slowly in the planting of this crop at least until they determine how the crop should be grown. Watermelons are even less desirable for planting in the subsistence garden because they require a large amount of space and a particular type of soil.

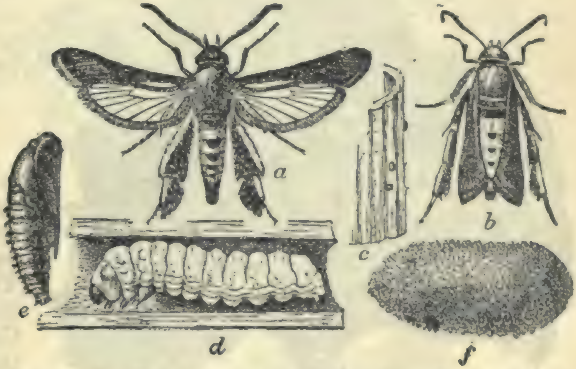

FIGURE 15.—Squash borer: *a*, Moth with wings spread; *b*, moth at rest; *c*, egg on section of vine; *d*, caterpillar or grub in squash vine; *e*, chrysalis; *f*, chrysalis cell from ground. Enlarged one-third. (Chittenden.)

DISEASES OF MELONS

Three important diseases—anthracnose, downy mildew, and blight—all ordinarily called " blight " or " leaf spot ", may attack the muskmelon when weather conditions are favorable, frequently resulting in heavy losses. All three diseases are caused by fungi. They often develop and spread rapidly in moist, warm weather and are characterized by brownish, more or less rounded or angular spots (fig. 16), which enlarge and soon cause the leaves to turn yellow, curl, dry up, and die. Watermelons are also subject to leaf diseases but not to the same extent as muskmelons.

Control.—Spraying the foliage thoroughly with bordeaux mixture is fairly effective in preventing the development of these leaf diseases.

The spraying should begin early or just as soon as the first leaves are formed and be repeated at intervals of every week or 10 days until the crop is all gathered.

INSECTS AFFECTING MELONS

The young seedling melon plants are subject to attack by the striped cucumber beetle the same as squashes, and the control measures are also the same.

Aphids or plant lice are especially troublesome on muskmelons (fig. 17) and to a considerable degree on watermelons. The control is the same as for squashes.

The squash vine borer will occasionally attack muskmelons, but the danger of loss is not as great as with squashes and pumpkins.

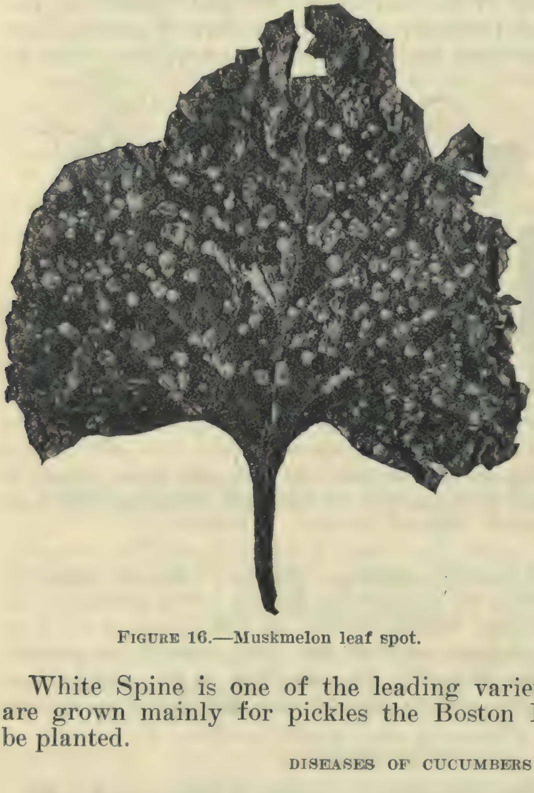

FIGURE 16.—Muskmelon leaf spot.

CUCUMBERS

Cucumbers, while not of great actual food value, should find a place in most subsistence gardens. They add variety and freshness to salads although there are certain people who cannot safely eat them. Cucumbers are also highly desirable for the making of pickles and relishes. The culture of cucumbers is the same as that for squashes and melons.

White Spine is one of the leading varieties. Where cucumbers are grown mainly for pickles the Boston Pickling variety should be planted.

DISEASES OF CUCUMBERS

The diseases of cucumbers are practically the same as those of muskmelons (see p. 39).

INSECTS ATTACKING CUCUMBERS

The striped cucumber beetle and the aphids or plant lice are the most troublesome insects on cucumbers. Cucumbers are sometimes killed by the squash vine borer. Splitting the stems and removing the grubs is the best known remedy.

SWEETPOTATOES

In the warmer sections of the territory to which this bulletin applies, especially along the Atlantic coast, and in Indiana, Illinois, Iowa, and Missouri, the sweetpotato is an important home-garden crop. While sweetpotatoes do not entirely take the place of potatoes they should be included in the garden plan wherever soil and climatic conditions are suitable for growing them. They require a rather light, warm, sandy soil, and while it is desirable to have plenty of decayed manure or organic matter in the soil the sweetpotato will respond very readily to the application of commercial fertilizers.

The plants with which to start the crop must either be grown from seed potatoes in a hotbed or they may be purchased from southern plant growers. The plants are usually set on ridges, the ridges being made 34 to 40 inches apart and about 8 inches in height but rather broad at the base.

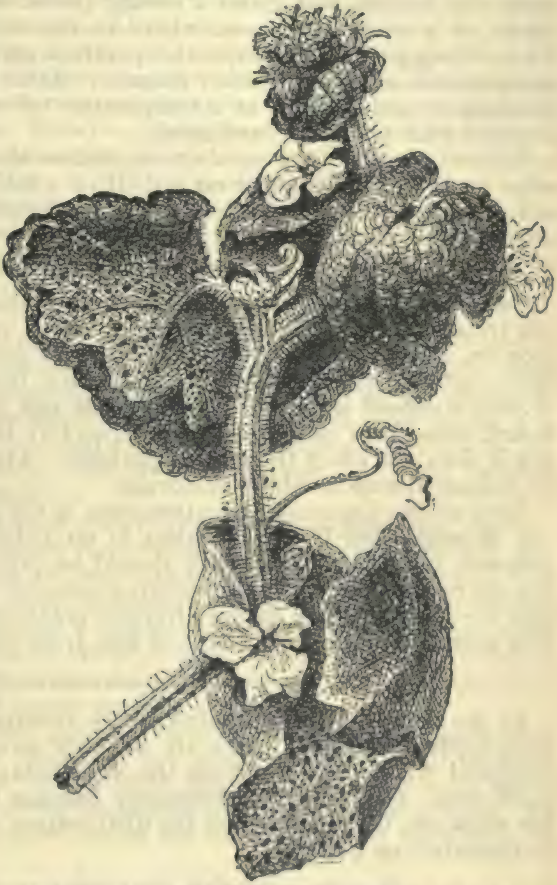

FIGURE 17.—Melon leaves curled by the melon aphid. (Chittenden.)

About an 8-quart pailful of fertilizer that is rather high in potash content may be sown to each 100 feet of row, being applied before the ridges are made up. The ridges should be made at least 3 or 4 days before the plants are set, but in case the ridges are not made until the time of setting the plants the fertilizer should be most thoroughly mixed with the soil before making the ridges. The plants should be set about 14 inches apart on the ridges and about a pint of water should be used around the roots of each plant as it is being set.

Sweetpotato plants should not be set in the open until all danger of frost is past and the ground is fairly warm. Yellow Jersey and

Bigstem Jersey are two of the leading varieties of the dry-fleshed type. Nancy Hall and Porto Rico are most frequently planted of the moist types of sweetpotatoes.

In the fall when frost kills the sweetpotato vines the potatoes should be carefully lifted from the soil with a spading fork or with some tool that will not bruise or damage them, and they should then be stored in a warm, well-ventilated place, preferably in crates or open slat baskets and given a curing period of about 10 days or 2 weeks at a temperature somewhere in the neighborhood of 85° F. This curing process dries out the potatoes and largely prevents the development of rots and other diseases. After the curing period the potatoes should be kept at a temperature of about 55°, but always dry and with plenty of ventilation.

Where only a few crates of sweetpotatoes are to be stored they can often be kept to advantage on a shelf or a table near the furnace in a dry basement, or near a heater stove in which a slow fire is kept during cold weather.

DISEASES OF SWEETPOTATOES

Sweetpotatoes are subject to a number of diseases, but only 2 or 3 are troublesome in the home garden. Black rot and scurf are common on all varieties and stem rot may be prevalent on the Jersey types, and on the Porto Rico and Nancy Hall. When the plants become diseased in the field, very little can be done to save them. Scurf, sometimes called soil stain, discolors the skin of the potato, but it does not affect the eating qualities. There are also a number of serious disease troubles in storage.

Most of the diseases of sweetpotatoes in the garden and in storage can be controlled if care is taken to set only clean plants. If the potatoes are to be stored they should be carefully handled during the operation of digging and storing in order not to bruise and injure the skin. Proper curing after the potatoes are placed in storage will greatly reduce the chances of loss from storage diseases.

INSECTS ATTACKING SWEETPOTATOES

In the more northern sections where sweetpotatoes may be grown in subsistence gardens there are no very serious insect pests to be reckoned with. In the South the sweetpotato weevil is a troublesome pest. Grasshoppers frequently damage the sweetpotato vines, but these can be controlled by the distribution of poisoned bran mash as described on page 10.

FRUITS FOR THE SUBSISTENCE GARDENS

Planting fruit of any kind on the subsistence homestead should be secondary to the establishment of the vegetable garden, but certain of the small fruits like strawberries, raspberries, blackberries, and grapes come into bearing comparatively quickly, and whenever the conditions are favorable these fruits should be planted as early in the program as possible. It is doubtful, however, if those who are undertaking subsistence farming should rush into the planting of tree fruits, and perhaps in the long run better results will be obtained by delaying the planting of fruit trees until time has been given to study the situation, to carefully select the location for the various trees, and to determine the best varieties to plant.

Another angle to the growing of fruit for home use is the problem of its protection from diseases and insects. There was a time when a fair grade of fruit could be grown without spraying or dusting, but that time has long since passed, and to be successful in the production of good fruit the grower must now follow a definite schedule of spraying or dusting in order to keep his trees free from insects and diseases.

It has been suggested that certain fruit trees might very properly be planted around the home, where they will serve both for shade and for the production of fruit to be used in the home. This use of fruit trees should, however, be very carefully studied before any planting is done, as overripe or decaying fruit has a tendency to attract flies and bees. Decaying fruit is also objectionable from a sanitary standpoint. As a general rule, tree fruits should be planted by themselves and where it will be most economical to give them the proper care, especially as regards spraying or dusting. The following pages contain brief instructions for the benefit of those who may desire to make an early start in the growing of fruits for home use.

STRAWBERRIES

Strawberries are adapted for growing in practically every part of the country, and come into bearing within a comparatively short time after they are planted. Plants that are set in the spring or early summer will give an abundant crop the following year. For the average family 100 to 150 plants will be sufficient at the beginning. These should be set in rows 3 or 3½ feet apart and 18 to 24 inches apart in the rows.

There are two systems of growing strawberries for home use—the hill system and the matted-row system. According to the hill system the original plants are set somewhat closer, and very few new plants are allowed to form, the plants being kept in distinct hills; according to the matted-row system, a large number of plants are allowed to form, and these are kept trained in the form of a matted row 12 to 18 inches in width, the plants being thinned or spaced so as to stand from 6 to 8 inches apart in the row.

In setting strawberry plants extreme care must be taken that they are not placed so deep that the hearts or crowns will be filled with soil during rains; on the other hand they should not be set so shallow that any part of the roots will be exposed above ground. In other words, they should be set at the same level that they grew in the original bed.

Strawberries require a moderately rich soil, especially one that is reasonably free from grass and weeds. They can be grown on all types of soils except those that are wet or extremely sour. Where there is any question about drainage the plants should be set on a slight ridge or bed. Where the plants are set during the early spring, the blossom stems should all be clipped off and no fruit allowed to set the first season.

There are many good varieties of strawberries, but certain of them are better adapted than others for the different sections of the country. The Premier, or Howard 17 as it is properly called, is perhaps the most universally grown throughout the northeastern United States. Recently a number of new varieties have been introduced, prominent among these being the Dorsett and Fairfax, especially for the northeastern section, and the Blakemore for the southern sections north of Florida. The season for ripe strawberries can be very materially extended by planting early, medium, and late varieties. Gardeners are advised to consult their local county agricultural agents as to the best varieties to plant in their respective sections.

While strawberry plants will produce their best crop the season following the setting of the plants, the bed may be cleaned out after the first fruiting season and carried over for another year. After the second year, however, it usually pays to start a new bed and plow under the old one. Where the bed becomes grassy or extremely weedy, it is difficult to renovate and carry it over. Many growers follow the practice of setting a small bed each year and destroying the old bed after it produces its second year's crop.

DISEASES AND INSECT ENEMIES

The diseases and insects of strawberries as encountered in the home garden are not especially important; the main point is to select good vigorous varieties that are adapted to each particular region. Strawberries are sometimes affected by certain leaf-spot diseases, but, as a rule, these troubles can be sufficiently overcome by good cultivation. The large white grub of the May beetle often does considerable harm; for that reason strawberries should not be planted on land where a heavy sod has been turned under, nor should fresh cow manure be used as a fertilizer.

RASPBERRIES

Raspberries are not recommended for extensive planting in the Southern States, and only the most hardy varieties are adapted for growing in the colder parts of the Northeastern and North Central States. This practically limits the growing of raspberries in home gardens to the North Central States and the parts of the Northeastern States where the temperature does not ordinarily go lower than 15° below zero. In northern Minnesota and the Dakotas, raspberries are frequently grown by laying down the canes in the fall and covering them with earth, and then uncovering them in the spring, but the winters are too severe in that section for growing raspberries by the ordinary methods.

One hundred hills or plants of raspberries will be an abundance for growing in the average home garden, and the grower has a choice among the black, purple, and red varieties. Among the black varieties most commonly grown in home gardens are the Cumberland, Plum Farmer, and Gregg; Cardinal, Columbian, and Royal Purple are leading purple varieties; and Cuthbert, Latham, Van Fleet, and Ranere (St. Regis) are among the best red varieties. The Van Fleet will grow well to the southward, while the Ranere is somewhat of an everbearer, producing an early summer crop which is sometimes followed by a fair crop in the late summer and fall. The Latham is a late berry of Minnesota origin and one of the most hardy of all the raspberry varieties.

Raspberries require a well-drained, rich soil with plenty of humus to prevent drying-out. In preparing the soil for planting it is a good plan to open a trench and work manure and a little bone meal or mixed fertilizer into the soil. The red varieties of raspberries are propagated by shoots that come up from underground roots. These are lifted and reset either in the fall or early in the spring before the buds start. The black varieties are started from tip layers where the tips of the canes bend over and touch the ground, take root, and start new plants. These new plants are lifted with a little soil around their roots and planted in a new location. New canes are formed each season and bear the crop of the following season, after which the old canes die and should be removed. The fall crop of the Ranere variety is borne on the tips of the new canes; then these same canes throw out branches and bear the crop the following season.

Raspberries should be given plenty of space; the rows should be 4 to 5 feet apart and the plants 3 feet apart in the rows. Two years are required after planting before any considerable crop will be borne; if the bed is kept clean and the plants well worked and fertilized, the plants should last for years. One of the real problems is to get plants that are free from crown gall and other root diseases. If the plants are purchased from a nursery the gardener should insist that they be guaranteed to be free from these diseases. Spraying the plants each winter with lime-sulphur solution will very largely control scale insects and bark diseases, but it is very essential that good plants be secured to start with. After a start is once made it is easy to produce all the plants required for replacements and new plantings.

Raspberry canes should be tied to stakes or wires so as to be held off the ground, especially during the fruiting period. The usual method of supporting the canes is to stretch wires on light posts about 30 inches aboveground and tie the canes to them.

Mulching the raspberry plants with coarse manure will aid greatly in holding soil moisture and at the same time help to keep down weeds.

BLACKBERRIES

Blackberries grow naturally throughout the greater part of the Northeastern States, and in many sections the wild varieties give fair results. However, it is better to plant 40 or 50 hills of one or more of the cultivated varieties. Blackberries require a deep, rich soil containing plenty of organic matter to hold moisture. In case the soil is poor and thin, some form of organic matter such as manure or decaying vegetable matter should be worked into it before the berries are planted. Blackberry plants should be set as early in the spring as the land can be worked, the plants used consisting of rooted shoots of the previous year's growth. They should be set as deep as, or perhaps just a little deeper than, they stood in the original patch or nursery. Plants set during the spring will produce a moderate crop the following spring and a good crop the second or third spring after setting.

Blackberry plants should be given 6 to 8 feet between rows with the hills 3½ or 4 feet apart in the rows. One method of planting blackberries is to place the rows about 8 feet apart; then grow vegetables such as cabbage or potatoes in the spaces between the blackberry rows. After 2 or 3 years, if the plants make a good growth, they will require practically all of the space. Blackberries require thinning because if all of the suckers are allowed to grow by the end of the second or third year the patch would be a dense thicket of blackberry canes just as they grow in the wild.

Some form of support is desirable; in fact, the plants should be either staked and tied, or wires should be stretched on posts and the canes tied to them.

Like raspberries, blackberries are greatly improved by mulching with straw or some coarse material that will help to conserve the moisture.

Blowers, Brainerd, Early Harvest, Eldorado, Lawton, and Snyder are among the leading varieties; however, because of the different behavior of the several varieties in various sections of the country it is always well to consult a local grower regarding the selection of varieties for any particular locality.

The cultivation of blackberries is not difficult and consists mainly of keeping the patch free from weeds and grass and heading back the new canes when they reach a height of 3 or 3½ feet in order to make them branch. The old canes should also be removed after they have produced their crop of fruit.

DEWBERRIES

Dewberries are grown practically the same as blackberries; however, they are not as hardy as blackberries, and only the most rugged varieties will stand the northern winters. Where blackberries are grown for home use it is scarcely worth while to grow dewberries in addition.

The Lucretia and Young dewberries are the main varieties for the South, but the former can be grown well to the northward if the canes are protected by covering during the winter. Unlike the canes of the blackberry, those of the dewberry are trailing, and it is necessary to tie them to stakes or to horizontal wires.

DISEASES AND INSECT PESTS OF RASPBERRIES, BLACKBERRIES, AND DEWBERRIES

Raspberries, blackberries, and dewberries frequently do very well without treatment for the control of diseases and insect pests.

Anthracnose.—If the disease known as anthracnose is serious, blackberries and dewberries may be sprayed with bordeaux mixture just as the buds are breaking, followed by two more applications at intervals of 2 weeks. For the control of anthracnose raspberries may be sprayed with bordeaux mixture once only, just as the leaves begin to show green. Additional applications are apt to cause serious injury.

Raspberry mosaic.—Raspberry mosaic makes the leaves crinkly and off color. Affected plants become nonproductive and should be promptly removed to save the others, as the disease is infectious. Plant only disease-free stock.

Rust.—An orange-colored rust attacks and destroys raspberry, blackberry, and dewberry bushes. Infected bushes should be removed at once. Insist upon getting disease-free nursery stock.

As a rule insects do not trouble raspberries, blackberries, and dewberries.

GRAPES

Grapes of one type or another can be grown in practically every section of the country. For planting in the South the Thomas and Scuppernong varieties are recommended, whereas in the northeastern section the American bunch grapes such as Concord, Niagara, Moore Early, and 1 or 2 others are recommended. The usual method of propagating grapes is by means of cuttings, and 1-year plants are as a rule used for planting. There are several methods of training grapes—on trellises, on arbors, and on posts. The two-wire trellis with the wires stapled to posts is undoubtedly best where fruit production is the primary object. Grape arbors serve a dual purpose of furnishing shade, and, under favorable conditions, growing large quantities of grapes. The danger of loss from diseases, however, is somewhat greater when the vines are trained on arbors than when they are on trellises.

One row of grapevines across the back of the lot or along one side of the garden is generally sufficient to supply all the grapes needed by the average family. This will require 8 or 10 vines, which should be planted fully 12 feet apart.

Grapes require a reasonably rich, well-drained soil, and they grow well when conditions are right for them. Manure and fertilizer may be used to enrich the soil in the beginning; then top-dressings of fertilizers and mulches of straw or some other material will aid in keeping the vines in a vigorous growing condition. Grapevines send their roots to considerable distances. They draw rather heavily upon the soil moisture and plant food and, if planted along one side of the garden, are likely to seriously affect the crops of garden vegetables.

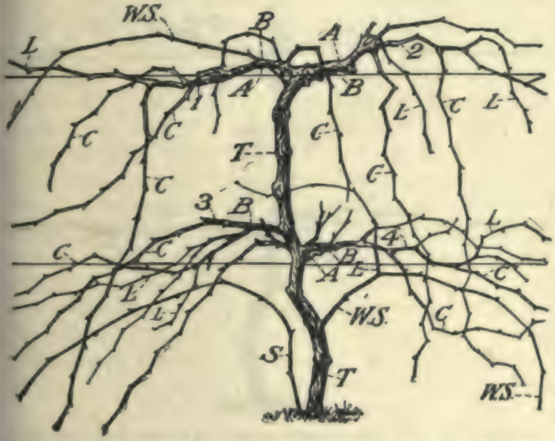

FIGURE 18.—Diagram of a grapevine before pruning, showing the different parts and illustrating the 4-arm system of training: *A*, Arms or ramifications of the branches, usually of wood 2 or more years old; *B*, branches which are of mature wood, being several years old; *C*, canes, called shoots when green and canes when mature; *L*, laterals, the secondary shoots of a cane; *S*, suckers, the shoots starting below the ground from the main body; *T*, trunk, the stem or main body of the vine; *W.S.*, water sprouts, the shoots which start above the ground from wood older than 1 year; *1, 2, 3, 4*, 2-year-old arms.

Grapevines grown on good land may produce a few bunches of grapes the second year after planting, but as a rule no considerable crop is obtained until the third or fourth year. Careful and systematic pruning of the vines is the secret of success in grape culture. Pruning should be done during the early winter and in case of the American or bunch grapes, such as Concord, Niagara, Moore Early, and Delaware, the shoots that grew the previous year should be cut back so as to leave about three good buds on each. These buds in turn will produce new shoots on which three or four bunches of grapes will be borne the following season. If too many buds are left on the vines the new growth will be weak and the bunches small. On a 3-year-old vine not more than 20 buds of last year's growth should be allowed to remain; on older vines 20 to 40 buds may be left, the number depending upon the vigor and strength of the vine. One principle that should be observed in the pruning of bunch grapes is to keep the bearing wood as near to the main stem of the vine as possible. By the usual method of training on wire trellises about 4 side branches, 2 in each direction, are allowed to remain. These in turn may form three or four lateral branches on which the crop is borne. The proper method of pruning a grapevine by the 4-arm system is shown in figures 18 and 19.

Where the 2-wire-trellis method of training is used the wires are stretched on posts, the first wire about 28 inches from the ground and the second wire at a height of about 4 feet. The vines are trained so that there will be side branches at the proper height to tie to these wires. This gives an ideal arrangement from the standpoint of spraying and picking the fruit. If these lateral branches eventually become too long and too old to produce good crops, new lateral branches may often be started from the main trunk of the vine and the old branches removed. This provides for a renewal of the bearing portions of the vines. In all cases the vines should be securely tied to the wires. A certain amount of pinching back and thinning out of the weak shoots is permissible during the growing season.

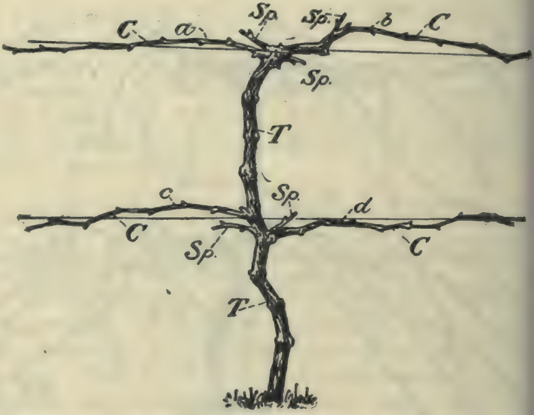

FIGURE 19.—A vine pruned according to the 4-arm system; *C*, Canes, called shoots when green and canes when mature; *Sp.*, spurs, canes cut back to 1 to 4 eyes; *T*, trunk, the stem or main body of the vine; *a*, *b*, *c*, *d*, arms succeeding those shown at their 2-year-old stage in figure 18 at *1*, *2*, *3*, *4*.

DISEASES AND INSECT PESTS

The principal diseases and insect pests of the grape, such as black rot, flea beetle, berry moth, etc., can be controlled by spraying with bordeaux mixture to each 5 gallons of which 3 level tablespoonfuls of powdered arsenate of lead is added. The first spraying should be applied when the young shoots have just started in the spring and are about 4 inches long, the second just before the blossoms open, the third just after the blossoms have fallen, and the fourth about a week later; for this application a tablespoonful of nicotine sulphate should be added to each 5 gallons of the spray to control plant lice.

Since these sprays are poisonous, the arsenate of lead and the nicotine should be omitted from applications made after the grapes become as large as garden peas, and all sprayed fruit should be thoroughly washed before it is eaten or offered for sale.

Covering the bunches of grapes with paper bags soon after the blooming period is an effective means of protecting them from most diseases and insect pests without the subsequent use of sprays.

Small flying insects known as leafhoppers frequently do great damage to grapevines. In most sections the grape leafhoppers may be controlled by the use of three-eighths of a pint of nicotine sulphate (40-percent nicotine) to 50 gallons of soapy water or bordeaux mixture. For small quantities, use three-fourths of a teaspoonful of nicotine sulphate per gallon of spray. The first application should be made when the wingless hoppers or nymphs of the first brood are present in large numbers (in the North this will be late in June or early in July), as can be determined by examination.

APPLES

Apples should not be planted on the subsistence farm unless conditions for their growth are reasonably good. Apples require a rather deep and fairly rich, well-drained soil, and they should be planted only on high ground where the air drainage is such that the blossoms will not be killed by late spring frosts. Apples require special spraying or dusting in order to protect the fruit and foliage from insects and diseases. Considering all these points, it is doubtful if a very large percentage of those engaging in subsistence farming will be justified in planting apple trees. Under reasonably favorable conditions, however, it may be desirable to plant a few trees, including 1 or 2 early varieties or 1 or 2 late summer and fall varieties, and about 2 or 3 late or winter varieties. It should be borne in mind that varieties differ with location, and in planting apples for home use the local growers who have had experience should always be consulted as to the best varieties. The county agent can usually give advice as to the best varieties to plant in a given locality.

It is seldom satisfactory to plant one apple tree with the idea of getting any considerable amount of fruit, unless nearby neighbors have apples on their places from which the bees may carry pollen to fertilize the apple blossoms. Very few varieties set fruit in abundance from their own pollen. Grimes Golden is self-fertile to a high degree, and in addition, this variety is extensively used as a pollinizer for other varieties. Where a single apple tree is grown, a crop of fruit may often be procured by cutting a few branches bearing the blossoms from some other apple tree known to be a good pollinizer, such as Grimes Golden, placing them in a pail or jar of water, and hanging them in the isolated tree where the bees may visit the blossoms and carry the pollen to the blossoms on the tree.

Apple trees eventually grow to considerable size and should be spaced at least 30 and preferably 35 to 40 feet apart. Well-grown, 2-year-old nursery trees are to be preferred for planting on subsistence farms. In planting apple trees, or any kind of a tree for that matter, it is important that the roots be protected from drying out during handling. Set the tree at the same depth or perhaps an inch deeper than it grew in the nursery, and be sure that fine, moist soil is well packed around the roots and that no air spaces are left. Fill the holes completely and tramp the soil, mounding it up a trifle to prevent the tree from being whipped about by winds. After the tree becomes established, the ground about it should be leveled and cultivation practiced.

The shape of an apple tree depends to some extent on the pruning it receives during the first 3 or 4 years after it is set out. It is during this period that the main or scaffold branches are established and the entire crown of the tree formed. In general, an apple tree should be pruned with more or less of an open head so that the sunshine may reach the inside of the branches.

For home fruit production, especially where the trees are to be used for shade, or where crops are to be grown in the spaces between the trees during the first 3 or 4 years, it is best to train the trees fairly high above the ground but not so high as to make spraying and picking the fruit difficult. Figure 20 shows a desirable form for a mature apple tree.

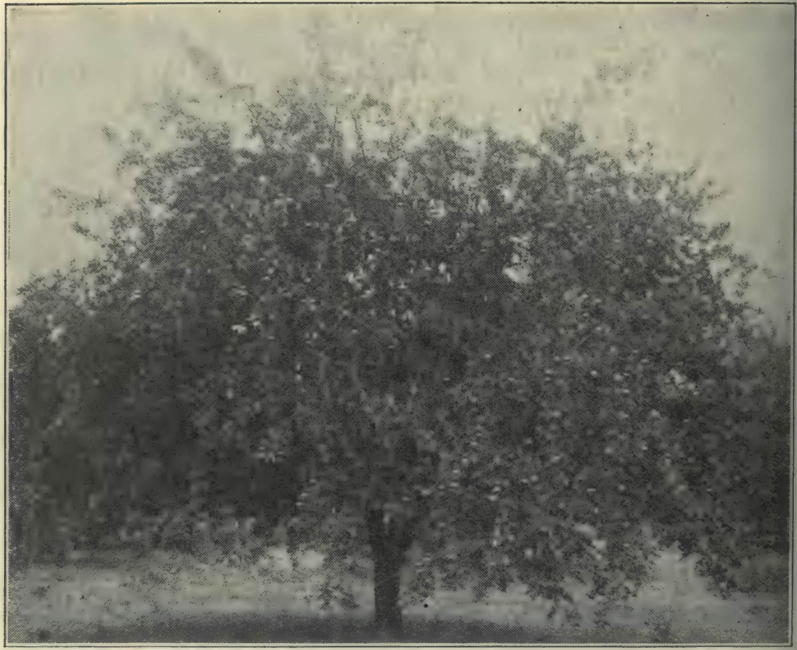

FIGURE 20.—A desirable form for a mature apple tree, such as may be developed by judicious pruning. This tree is about 30 years old.

PEARS

Pears are somewhat better adapted for growing in the subsistence garden than are apples, because they require less space and come into bearing at an earlier age. Pears do not require as rich a soil as apples or peaches, in fact, if they are planted on rich soil or given applications of fertilizers and clean culture they are very likely to be attacked by blight. The varieties of pears to be planted in the subsistence garden will depend upon locality, but the Bartlett, Seckel, and Angouleme are among those most commonly planted in northern sections. The Bartlett is undoubtedly the choicest market and home variety, but it is extremely susceptible to blight. The Kieffer variety is less susceptible to blight, and while the fruit is of inferior eating quality to that of the Bartlett it is a heavy bearer and the fruit is of fair quality for canning and preserving. One r two trees of the Kieffer variety will generally be sufficient to fur- ish all of this class of fruit required by the average family. The uality of Kieffer pears is greatly improved by picking them care- ully to avoid bruising and then storing at a temperature of 60° F. ntil they soften slightly.

Pear trees may be spaced 20 to 25 feet apart and should be located n ground that is not used for the growing of any cultivated crop.

DISEASES AND INSECT PESTS OF APPLES AND PEARS

Most diseases and insect pests of the apple and pear, such as scab, ot, the various leaf spots, San Jose scale, codling moth or apple orm, and caterpillars, can be largely controlled by spraying. Dusts ay be used instead of sprays in all applications except for the dor- ant or winter sprays, and while not generally so effective during e growing season as the sprays, they are more easily and rapidly pplied. The following schedule will give control of the more im- ortant diseases and insect pests:

1. Lime-sulphur, 1 pint to 1 gallon of water or 3-percent oil emulsion, to be pplied before growth begins in the spring.
2. Lime-sulphur, 1 pint, and arsenate of lead, 15 rounded teaspoonfuls in 5 llons of water, or 3 rounded teaspoonfuls per gallon, or a dust composed of usting sulphur, 9 parts, and arsenate of lead, 1 part by weight, to be applied) just before the blossoms open, (*b*) just after the petals have fallen, (*c*) to 4 weeks later, and (*d*) 3 weeks later.

It must be remembered that, since these sprays and dusts are oisonous, all fruits treated with them should be thoroughly washed fore being eaten or offered for sale. The same sprays may be used n sour cherries at the same time, but not on peaches, plums, and veet cherries. The sprays recommended on page 53 for peaches and lums may also be used safely on apples, pears, cherries, and apricots; ey will not control apple and pear pests as well as the lime-sulphur d oil sprays, but if one set of sprays is desired for all these fruits, e set recommended for peaches and plums should be used. All tten, wormy, and scabby fruit should be removed from the tree from the ground and destroyed.

Cankers.—Cankers or dead areas in the bark should be carefully moved with a knife or carpenter's gouge, in the same way that the nkers caused by pear blight are removed.

Blight of apples and pears.—Apples and pears are subject to an fectious disease which causes blossoms and twigs to turn black and e in the spring, and makes dead areas in the bark of large limbs and unks. Infected twigs should be removed as soon as they show any fection; they should be cut about 6 inches below the infected areas, e dead areas of bark should be removed with a knife or carpenter's uge, the cut extending well back into living bark. The tools ould be sterilized after each cut by being swabbed with a 1 to 1,000 lution of corrosive sublimate obtainable at any drug store. Large ounds should be painted over with ordinary house paint or with al tar thinned with creosote.

Cedar rust of apple.—Orange-colored spots on the leaves and fruits the apple are produced by a fungus that must live during part of life on the red cedar. Removing the cedar trees in the vicinity of e orchard is the only practical remedy, but this is frequently not actical for small plantings.

PEACHES

Peaches are among the most uncertain of the tree fruits that may be planted in the subsistence garden. The trees come into bearing the third or fourth year after planting. They seldom live more than 20 years, and crop failures due to the killing of the blossoms by frost are of very common occurrence. Commercial peach growers consider that if they can secure a crop 3 years out of 5 they are doing very well.

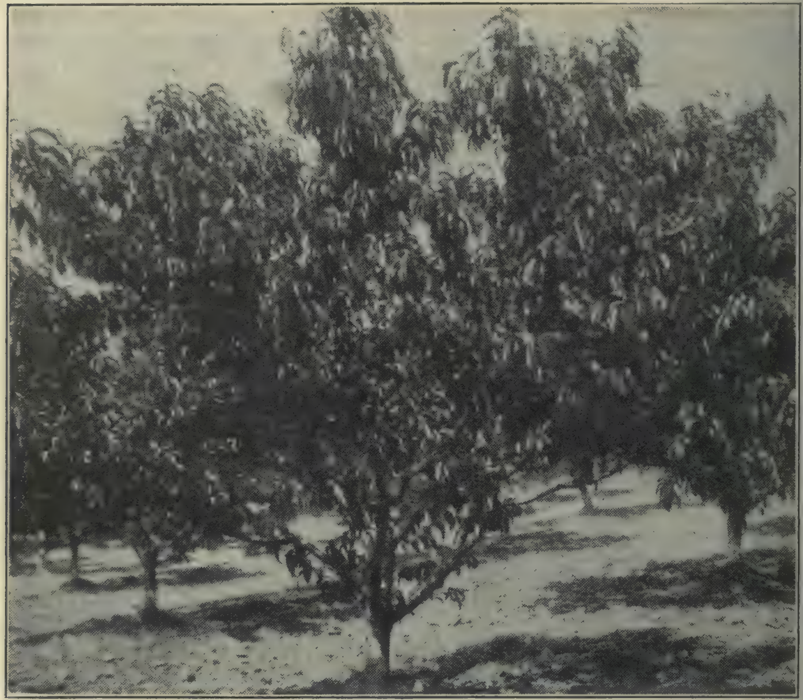

FIGURE 21.—A well-formed, 6-year-old peach tree which has had systematic pruning.

Among the varieties of peaches that may be planted in many sections in the subsistence garden are Belle and Elberta, although numerous other varieties are grown in special localities. The grower is advised to seek the advice of some experienced fruit grower before making up his list of varieties.

Peach trees should be planted 16 to 20 feet apart and given clean, careful cultivation throughout their life period. The trees require pruning every season in order to prevent the formation of too many buds, which result in a thick growth and the production of small fruit. This pruning usually takes the form of thinning out the branches and opening up the head of the tree so as to admit plenty of sunlight and at the same time prevent the tree from becoming too tall for convenience in thinning and picking the fruit. Wherever there is a heavy set of fruit, the fruit should be thinned so that the individual fruits will be 4 to 6 inches apart on the branches. A good type of peach tree is shown in figure 21.

PLUMS

Plums are well adapted for growing on the subsistence farm, specially in the poultry yard and in out-of-the-way places where hey will not seriously interfere with other crops.

Lombard, Reine Claude (Green Gage), German Prune, Shropshire (Damson), Abundance, and Burbank are among the varieties commonly grown in the North and the northeastern sections of the ountry. Certain varieties of plums, like Burbank, have a spreading abit of growth and should be planted about 15 feet apart; others, ike Shropshire, are more upright in their habit of growth and may e planted as close as 12 feet apart.

Plums require a fairly rich soil and do best when they are given ood clean cultivation.

CHERRIES

Wherever climatic conditions are suitable cherries are probably he most desirable of all tree fruits for growing in the subsistence arden. They require the same soil and cultural conditions as apples. he trees may be planted as closely as 20 or 25 feet without serious rowding. However, cherry trees sometimes live to a great age and ecome quite large; in that case every second tree can be removed. rom the standpoint of pollination, cherries, especially sweet cherries, re like apples, and it is necessary to have trees of more than one ariety growing near each other in order to secure satisfactory crops f fruit. Cherries are not adapted for growing in the southern istricts.

Among the sour cherries Early Richmond and Montmorency are he leaders, although English Morello is still planted as a late variety. Among the sweet varieties Black Tartarian, Yellow Spanish, nd Windsor are popular in the sections to which this bulletin pplies.

DISEASES AND INSECT PESTS OF THE PEACH, PLUM, AND CHERRY

Certain diseases and insect pests of the peach, plum, and cherry, ich as scab, rot, the San Jose scale, leaf curl, and the plum curculio, an be controlled by spraying or dusting as follows:

1. Spray with lime-sulphur, 1 pint to 1 gallon of water, before the buds begin swell in late winter, or in the fall after all leaves are gone. Dusts used at is time are not effective.
2. Spray with wettable sulphur one-half pound and arsenate of lead 15 unded teaspoonfuls in 5 gallons of water, or 3 rounded teaspoonfuls per llon, or dust with dusting sulphur 9 parts and arsenate of lead 1 part (*a*) out 10 days after the blossom petals have fallen or when the shucks have en shed by the young fruits and (*b*) about 2 weeks later.
3. Spray with one-half pound of wettable sulphur in 5 gallons of water, or ist with dusting sulphur about 2 to 4 weeks before the fruit is expected to pen. No arsenate of lead should be used in this application.

Since these sprays and dusts contain poison, all sprayed fruit ould be washed thoroughly before it is eaten or offered for sale. These sprays may also be applied to other fruit trees with safety. s a clean-up measure, all diseased or wormy fruit should be picked om the trees and from the ground and destroyed.

Plum and cherry black knot.—The large black warty growths o limbs of plum and cherry trees should be removed and destroyed a soon as recognized by cutting off the affected limb at least 6 inche below the knot. Winter spraying with bordeaux mixture prevent infection.

Insects.—There is another very important group of insects tha attack peach, plum, and cherry trees. These insects damage the bar or sapwood of the trunk and branches of the trees, and their presenc is usually indicated by the formation of gum, commonly known a "gummosis."

The peach borer is considered the most devastating of these insects It works mainly at the base of the tree. The presence of these borer can be detected by the presence of the gummy formation, and if careful examination is made the worms will be found cutting tunnel in the bark of the tree trunk at the ground level. The trees shoul be examined during the early spring and again late in the summe and the worms removed by means of a sharp-pointed knife or a wire About 1 ounce of paradichlorobenzene,[2] may be spread in a rin around the base of the tree and then mounded over with earth. I northern localities this should be done during August but later in th South. The gas formed by this chemical, which is similar in appearance to naphthalene flakes, will smother the worms in their tunnels It should not be used around trees that are less than 4 years old.

Other bark-eating insects of the peach in particular are bar beetles and shot-hole borers. The presence of these insects is als indicated by the exudation of the gum from the trunk and branche of the trees. In cases of severe infestation the trees are reasonabl sure to be killed and should be removed and burned.

REFERENCE PUBLICATIONS

Farmers' Bulletin No. 879, Home Storage of Vegetables.

Farmers' Bulletin No. 1001, Growing Fruit for Home Use.

Farmers' Bulletin No. 1044, The City Home Garden.

Farmers' Bulletin No. 1242, Permanent Fruit and Vegetabl Gardens.

Farmers' Bulletin No. 1246, The Peach Borer.

Farmers' Bulletin No. 1371, Diseases and Insects of Garden Vegetables.

Farmers' Bulletin No. 1762, Home Canning of Fruits, Vegetables and Meats.

Farmers' Bulletin No. 1673, The Farm Garden.

Miscellaneous Publication No. 136, Conservation of Fertilize Materials from Minor Sources.

Leaflet No. 70, Home Mixing of Fertilizers.

Any of the above bulletins, with the exception of Farmers' Bulleti No. 1673, which is priced at 10 cents, may be secured from th Superintendent of Documents, Government Printing Office, Washington, D. C., by sending 5 cents in coin for each copy.

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[2] See Farmers' Bulletin 1246, The Peach Borer.

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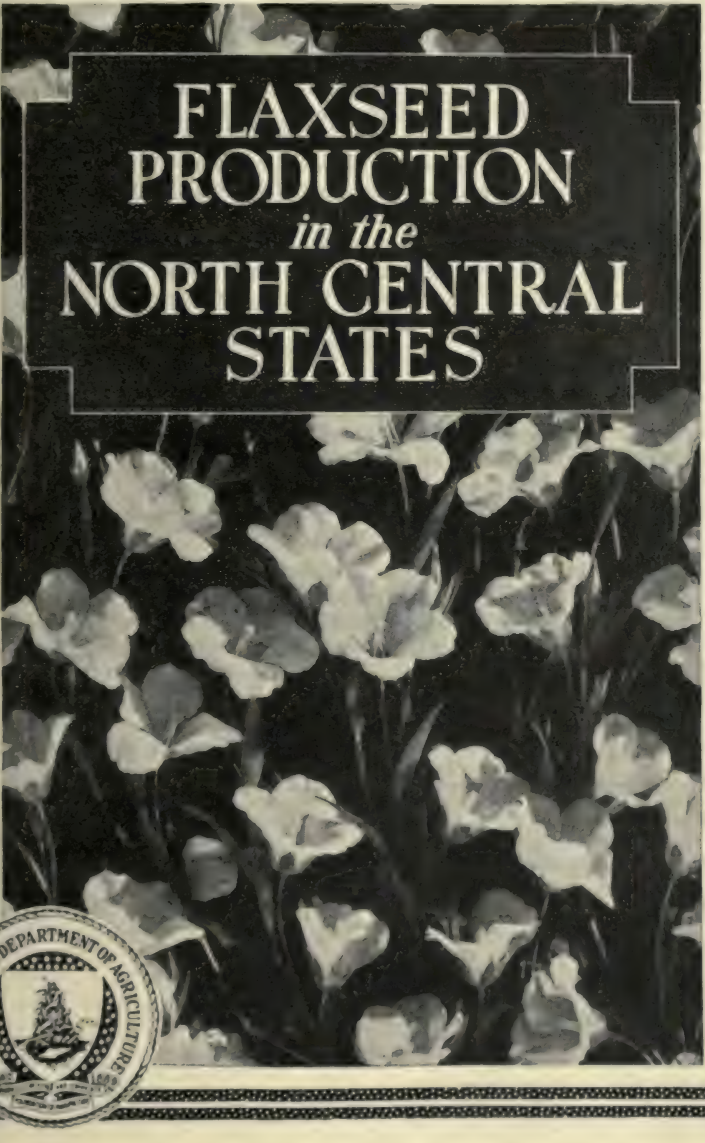
U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1747

FLAXSEED PRODUCTION *in the* NORTH CENTRAL STATES



FLAX IS GROWN both for fiber and for flaxseed, or linseed. It is the purpose of this bulletin to give information in regard to the production of flaxseed in the North Central States, where the crop is grown most extensively. Formerly flax was grown chiefly on new lands, but with the development of wilt-resistant varieties it is now possible to grow it frequently on the same land in short-time rotations with other crops.

It is important that flax be grown on clean land. Flax does well following corn that has been given thoroughly clean cultivation. A rotation that includes a small grain and a legume crop such as sweetclover, red clover, soybeans, or field peas, followed by corn and finally by flax, is very satisfactory.

Flax is primarily a cool-climate crop. As a general rule, therefore, it should be sown early, as it is benefited by the cooler growing season of early summer.

Bison flax is the leading commercial variety. It is remarkably resistant to flax wilt, and its medium-large seeds yield a high percentage of oil.

Flax for seed production is sown at the rate of fully 3 pecks (42 pounds) an acre in Minnesota, but at a somewhat lower rate in the drier western part of the flax-producing area. A good stand of flax helps to control the growth of weeds.

This bulletin is a revision of and supersedes Farmers' Bulletin 1328, Production of Seed Flax.

Washington, D. C. Issued September 1935

FLAXSEED PRODUCTION IN THE NORTH CENTRAL STATES[1]

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INTRODUCTION

THE FLAX PLANT (*Linum usitatissimum*) is the source of two valuable products, flaxseed and fiber. In practice, however, distinct types or varieties of flax are grown, depending on whether the seed or the fiber is the principal product desired. This bulletin treats of growing the crop only for the seed, from which linseed oil is made. The coarse straw of seed flax, as usually grown, does not yield a fiber suitable for spinning.

Flax is an annual plant that grows to a height of 12 to 40 inches. It has a distinct main stem and a short taproot. The slender root branches, however, may extend to a depth of 3 to 4 feet in light soil. In thick seeding, as for fiber flax, only the main stem develops, whereas in thin stands two or more branches may arise from the base of the plant. The flax flower has 5 petals and a 5-celled boll or capsule, which when filled contains 10 seeds but not more than 10 except in abnormal double bolls.

Normally, flax is self-pollinated, and very little natural crossing occurs. The flowers open at sunrise on clear warm days, and the petals fall before noon. The petals are blue, pale blue, white, or pale pink in different varieties. The seeds usually are light brown, although in certain varieties they are yellow, mottled, greenish yellow, or nearly black.

Flaxseed yields from 32 to 44 percent of oil, based on dry weight. In commercial crushing about 19 pounds, or 2½ gallons, of oil are obtained from a bushel (56 pounds) of seed. A part of the oil, 3 to 6 percent, remains in the cake. The percentage yield of oil depends on the type or variety of flax and on the climatic conditions under which the crop is grown. If drought occurs when the seed is filling, that is, within a period of about 30 days after blossoming, the seed may be shrunken and the oil content low. High temperatures, which often accompany a period of drought, are especially injurious to flax, since they reduce the acre yield and the percentage of oil. In general, the large-seeded varieties yield a higher percentage of oil than do the small-seeded varieties. On the other hand, the small-seeded varieties may produce oils of a somewhat better drying quality, as indicated by a higher "iodine number." The iodine number is a chemical test which indicates the drying quality of the oil, or, more exactly, the quantity of oxygen the oil will absorb in drying to form the characteristic oil or paint film. Both the quantity and quality of the oil are influenced by the climate, especially by the amount of rainfall and the temperature under which the crop is grown.

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[1] Cooperative investigations carried on by the Bureau of Plant Industry, U. S. Department of Agriculture, and the North Dakota Agricultural Experiment Station.

HISTORY OF FLAX IN THE UNITED STATES

Flax grown for fiber was one of the first crops introduced from the Old World. In colonial times nearly every household had its patch of flax, and flax continued to be grown to some extent for home use as late as 1840. The manufacture of linseed oil was begun in the United States as early as 1805.

Until recent years flax has been a pioneer crop in the history of American agriculture, and the center of production has always been near the frontier. The census of 1850 showed Ohio and Kentucky to be the leading flaxseed-producing States, but by 1900 the center of production had shifted to North Dakota. During those 50 years the crop had migrated with the advance of settlement from Ohio across Indiana, Illinois, Iowa, and Minnesota to North Dakota. This shift in areas of production was partly due to the injurious effect of flax wilt in the older cultivated lands, but chiefly to the economy of production on the fertile virgin soils of the middle Northwest.

In recent years the production of flaxseed in the United States has been insufficient to meet the requirements of domestic industries, and large quantities have been imported, chiefly from Argentina. The tariff act of 1930 provides a duty of 65 cents a bushel of 56 pounds on imported flaxseed and 4½ cents a pound on linseed oil. Under the previous tariff act (1922) the duty was 40 cents a bushel on flaxseed and 3.3 cents a pound on linseed oil. The annual production, net imports, and consumption of flaxseed in the United States from 1921 to 1933 are shown in figure 1.

THE FLAX-GROWING AREA

Flax is grown under a wide range of soil and climatic conditions but does best on the clay loam soils of the North Central States where the summer temperature is moderate and the rainfall adequate. The area of flaxseed production in 1929 is shown in figure 2. North Dakota, Minnesota, South Dakota, and Montana produce approximately 95 percent of all the flaxseed grown in the United States. In Minnesota and eastern North Dakota, the center of the flax-producing area, the rainfall ranges from 18 to 30 inches. The precipitation diminishes westward to about 15 inches in eastern Montana. In the entire flax-producing area the crop depends largely upon the summer

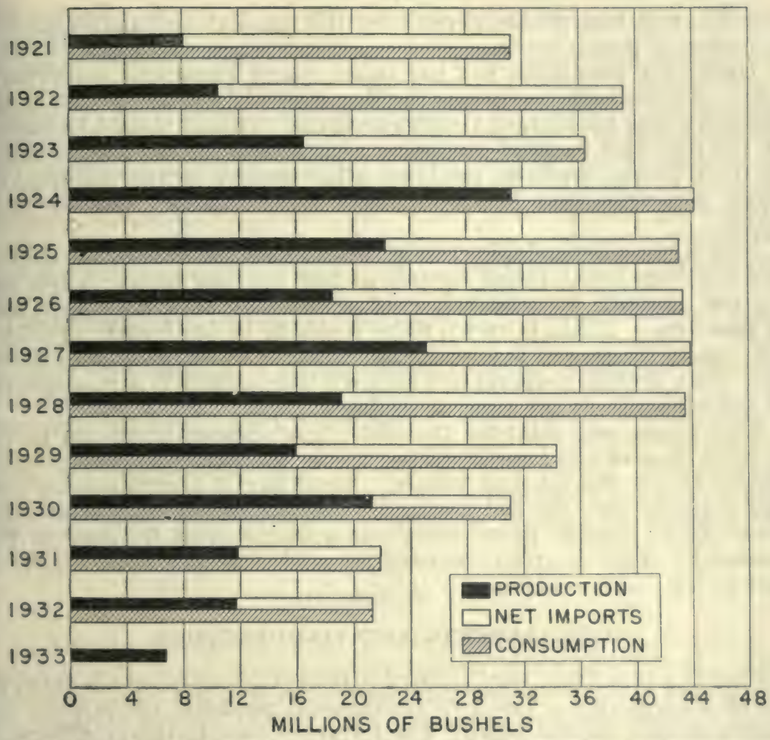

FIGURE 1.—Flaxseed production, net imports (including linseed oil in terms of seed), and consumption in the United States for the 13-year period 1921–33.

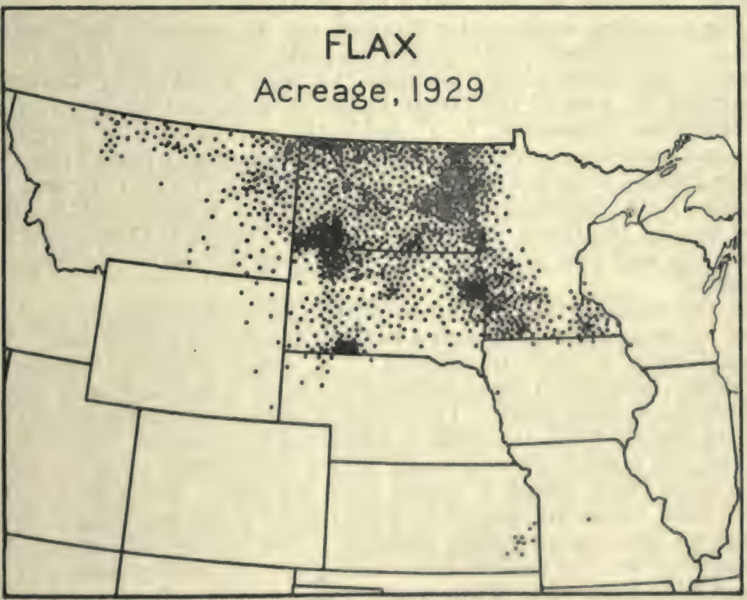

FIGURE 2.—Distribution of flaxseed production in 1929. Each dot represents 2,000 acres. Estimated area, 347,000 acres.

rainfall, and high yields depend on the amount and favorable distribution of precipitation.

Under dry conditions flax has short, coarse straw and nonuniform fiber. Under such conditions the flax is of little value for fiber, and therefore only the highest yielding seed-flax varieties should be grown. In the principal flaxseed-producing area, where the annual rainfall is 25 to 30 inches, seed flax produces a fair quality of fiber suitable for those industries that heretofore have used imported flax tow and waste.

Flax is not a dependable crop in the dry-farming area of the central and southern Great Plains because of high summer temperatures and limited rainfall. In relatively cool, moist seasons it may yield well in that area. If flax is grown there it should be sown early so that it may make its growth before the hot weather of early summer comes on. Flax probably should not be sown unless there is a good supply of soil moisture at the time of seeding.

Flax is not well adapted to cultivation without irrigation in the western part of the United States, where the principal precipitation occurs during the fall and winter. Since flax is a spring-sown crop and matures late, the soil moisture stored from winter precipitation generally is insufficient to carry the growing crop through to full maturity. Flax is grown successfully under irrigation in the West and in the Southwest.

USES, MARKETS, AND MANUFACTURE

Flax is a cash crop, very little of it being consumed on the farm on which it is grown. The two commercial products of flaxseed are linseed oil and linseed meal. The former is used in the manufacture of paints and varnishes, linoleum, oilcloth, printer's ink, patent leather, imitation leather, and other products.

The principal markets for flaxseed are Minneapolis and Duluth, Minn. The linseed mills at Minneapolis consume the bulk of the flaxseed marketed there, whereas the seed received at Duluth is reshipped by way of the Great Lakes to mills at Chicago, Buffalo, Philadelphia, Edgewater, N. J., and in the vicinity of New York City. The eastern mills also crush imported flaxseed, chiefly from Argentina. Other linseed mills located at Red Wing, Minn.; Sioux City and Des Moines, Iowa; Milwaukee, Wis.; and Fredonia, Kans., crush the flaxseed locally produced, while the mills at Portland, Oreg., and San Francisco and Los Angeles, Calif., use both domestic and imported flaxseed.

In the manufacture of linseed oil the flaxseed is ground to a fine meal by being passed through a battery of revolving steel rolls. The ground meal is then transferred to a steam-jacketed cylinder or "cooker", live steam being added if the meal is very dry, and heated to near the boiling point. This heating process facilitates the expression of the oil when the meal is subjected to pressure. After being heated, the meal is pressed firmly into a mold about 13 by 32 inches on a press cloth, which is folded over the cake. From 24 to 30 of these meal cakes are placed in a hydraulic press and subjected for about an hour to increasing pressure. The presses are operated in batteries of six, the smaller mills having 12, 18, or 24 presses and the larger mills from 48 to 96 or more. The residue left after the oil is expressed is known as linseed cake, or, if ground, as linseed meal. The cake contains from 3 to 6 percent of oil, depending on the efficiency of the pressing.

A more modern type of press, known as the cage type, is efficient and economical of operation. The cage consists of a heavy steel cylinderlike drum about 6 feet high and oval in cross section, the walls being slotted to permit the escape of oil in pressing. The cage is filled with successive layers of ground flaxseed meal placed between press cloths and then subjected to hydraulic pressure by means of a heavy plunger. In another type of press, known as an expeller, the meal is fed into the machine and the oil expressed as a continuous process. This press is considered economical of labor but is somewhat less efficient than the presses described above in extracting the oil.

The extraction of linseed oil with naphtha, a solvent obtained from petroleum, was made use of to some extent a few years ago. This so-called "new process" was more effective than the pressing methods in extracting the oil from the ground flaxseed, leaving less than 2 percent in the meal. As the fire hazard was great and several mills were burned, the naphtha process has been discontinued in the United States. Moreover, livestock feeders generally prefer the ordinary "old process" linseed meal because of its higher oil content, which makes it mildly laxative and is believed to produce the glossy coats of animals to which it is fed.

VARIETIES OF FLAX

As already mentioned, there are two fairly distinct purposes for which flax is grown commercially, namely, fiber and linseed. The fiber flaxes are tall and early maturing and have small seeds. As flax for fiber is sown thickly, the stems are small and without basal branches. Fiber flax is never grown primarily for linseed; however, the seed that is not required for sowing the fiber crop is sold on the market for crushing.

The seed-flax or linseed group consists of several more or less distinct types: (1) Wilt-resistant, short-fiber flaxes; (2) common or so-called "Russian"; (3) Argentine; (4) Indian; (5) Abyssinian; (6) Golden or yellow-seeded; and (7) a few others of less commercial importance.

Nearly all varieties now grown commercially in the United States belong to the wilt-resistant, short-fiber type and have been developed by selection on the basis of wilt resistance and high seed yield. Linota, Buda, and Redwing belong to this group. These varieties are of midheight, have small brown seeds, and are moderately wilt-resistant. They have, however, been replaced largely by Bison, which is exceptionally resistant to flax wilt.

Bison flax was developed by H. L. Bolley and his assistant, Ole Heggeness, at the North Dakota Agricultural Experiment Station, Fargo, N. Dak. Seed was first distributed to farmers in 1926, and by 1931 it had become the leading commercial variety in the United States. Bison has rather stout stems of midheight, medium to large brown seeds, and deep-blue flowers. The medium-large seeds of Bison generally yield a higher percentage of oil than do the small-seeded varieties Buda, Linota, and Redwing.

Seeds of six important commercial varieties of flax are shown in figure 3.

Redwing, developed at the Minnesota Agricultural Experiment Station, is very early and moderately wilt-resistant and rarely lodges even when grown in rich soil. It can be distinguished in the field by its light-blue flowers. It has small brown seeds that yield an oil of good drying quality. It appears to be well adapted to southern Minnesota and Iowa and has proved to be a valuable variety where early maturity is required, as at Bozeman, in the Gallatin Valley of Montana, and at Edmonton, Alberta, Canada.

The common or "Russian" varieties formerly were grown extensively on new lands in the Dakotas, but owing to their susceptibility to wilt they have been largely replaced by wilt-resistant varieties. Damont, Reserve, and Newland are varieties or strains selected from Russian N. D. No. 155. They are not wilt-resistant. Newland is grown in Montana, where flax wilt is rarely a problem. It is immune from rust.

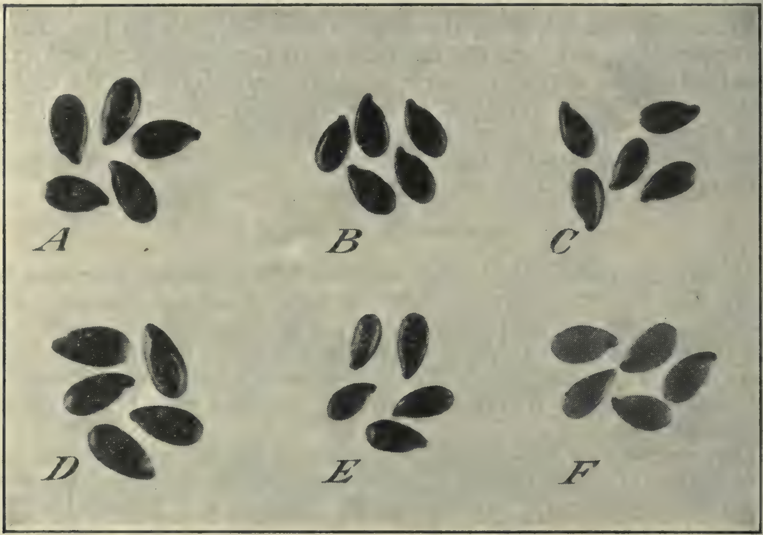

FIGURE 3.—Seeds of the principal commercial varieties of flax: *A*, Bison; *B*, Redwing; *C*, Linota; *D*, Argentine; *E*. Buda; and *F*. Bolley's Golden (C. I. 644). These seeds can be identified by their size, color, and shape. × 2.

The Argentine flax of commerce is not well adapted to the northern flax-producing area of the United States, where the growing season is comparatively short. In Argentina flax is sown in the fall or winter (May–July) and has a growing period of 5 or 6 months. As grown in Minnesota and the Dakotas, the plants of the Argentine variety generally are short, and in hot seasons many of the flowers blight and the bolls are poorly filled. Selected strains are more or less resistant to flax wilt, and most strains are immune from flax rust.

The Indian, Abyssinian, and Golden or yellow-seeded flaxes all are short and generally much-branched linseed types. As grown in Minnesota and North Dakota, they are usually too short to be harvested readily with the binder. Several varieties and hybrid selections of yellow-seeded flax have been grown experimentally, but so far none has equaled the better commercial varieties in disease resistance or in yield of seed. The Indian, Abyssinian, and yellow-seeded varieties have been grown occasionally by farmers in the North Central States, but these types have never become established on a commercial scale.

GROWING THE CROP

PREPARING THE SEED BED

Flax requires a firm seed bed. Poor stands often are due to seeding too deep in loose soil. Sod broken in the fall or spring should be packed by heavy rolling or by disking, harrowing, and rolling, and the surface should be made level before being seeded. Sod land should be prepared as soon as possible in the spring in order that the seed may be sown before the turned sod becomes dry. Where tractor outfits are used, plowing, disking, harrowing, packing, and seeding often are done in one operation. Pasture and meadow lands usually should be broken late in the summer. The rough sod will catch and hold the snow, frequent freezing and thawing will mellow the sod, and the land can be put in condition for early seeding.

A firm seed bed is as essential when flax is grown in rotation with other crops on old land as it is on sod land. For this reason corn ground usually is disked instead of plowed in preparation for flax. If spring plowing is necessary, the land should be made firm by rolling or disking, with the disks set nearly straight.

Whether fall or spring plowing of stubble land is best for flax depends on the conditions under which the crop is to be grown. In the humid area fall plowing and early spring seeding generally are considered best. In the drier areas the winter cover of stubble catches and holds the snow, which adds moisture to the soil. Under such conditions spring plowing may give the best results.

A firm, even seed bed permits the seed to be sown at a uniform depth. All harrowing should be done before seeding. Harrowing after the drill covers many seeds too deep and prevents the young plants from reaching the surface.

METHOD OF SEEDING

Flax generally should be sown with a grain drill at a depth of about 1 inch. A drill with press attachments is most satisfactory, as it presses the moist soil around the seeds, thus insuring even germination. A soil packer that can be attached to any grain drill is shown in figure 4. When it is necessary to sow on loose soil, it is sometimes desirable to release the pressure springs on the drill and depend on the weight of the disks to place the seed at the proper depth.

In seeding wheat or other grain with flax, the two kinds of seed are mixed in the desired proportions at the granary and sown together about 1 inch deep. Usually alfalfa or clover is sown with a grass-seeding attachment to the drill, although the seed of these plants can also be sown readily when mixed with flax.

TIME OF SEEDING

Formerly it was a common practice to seed flax late on sod land or as a catch crop on old land. This has led many growers to believe that flax should not be sown early. On the contrary, experiments show that early seeding generally produces higher yields. Early seeding allows the crop to make its growth during the cooler weather of spring and early summer, when it makes the most efficient use of the soil moisture.

Flax in the seedling stage is not easily injured by frost. Seedlings just emerging are most tender, but even these will endure a moderate frost, especially if the soil is moist and they are not further injured by drying winds. After the plants are 2 or 3 inches high and are hardened by exposure they will endure a temperature of 20° to 22° F. for a short time without injury. The degree of injury is dependent on the minimum temperature, the condition of the plants, the soil moisture supply, and the weather conditions after freezing.

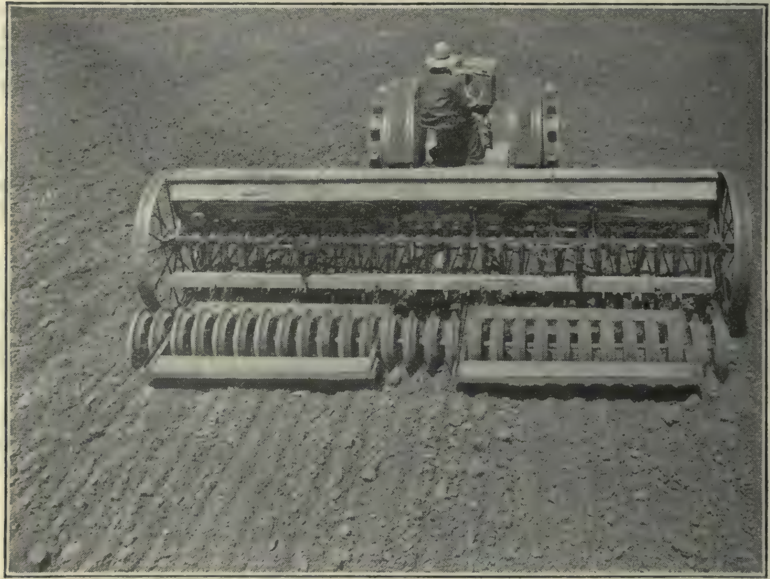

FIGURE 4.—A type of packer with wedge-shaped wheels designed to firm the soil and still leave the surface somewhat ridged to prevent soil blowing. The packer can be attached to any grain drill.

Flax in the green-boll stage is readily injured by heavy frosts, which may occur late in the summer or at high altitudes. The green seeds, which contain from 50 to 75 percent of moisture, are killed by freezing temperatures, although the leaves and stems of the plants may not be injured. The writers have seen fields of green flax that appeared quite normal, but on examination the seeds were found to be shrunken, worthless, and dead.

Experiments in the northern Great Plains area indicate that flax sown during the first part of May usually produces the highest yield. For best development flax requires cool weather at the time of blossoming and ample moisture until ripening begins. Such conditions are most likely to prevail at blossoming time if the seed is sown early. Flax may be sown during the first week of June, however, with fair assurance that it will ripen before frost. Later seeding often results in low yields, even though the crop escapes frost. Plots of flax sown at intervals of 15 days from May 1 to June 1, at Mandan, N. Dak., in 1922, are shown in figure 5.

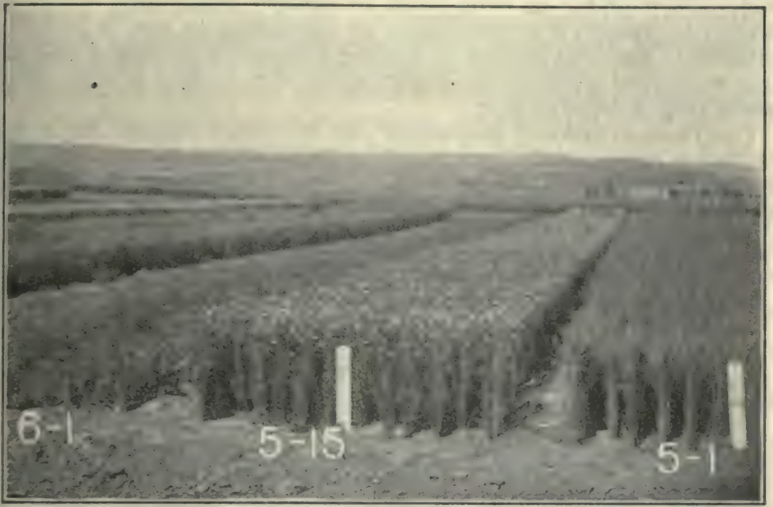

FIGURE 5.—Plots of flax sown at intervals of 15 days from May 1 to June 1, 1922, at Mandan, N. Dak. The plot sown on May 15 was in full bloom when photographed on July 7, 53 days after being seeded.

It often is an advantage, especially where Russian-thistles, wild oats, and other early weeds are abundant, to cultivate the land with a field cultivator, disk, or harrow in order to germinate seeds and to destroy the weeds before seeding flax. On the other hand, where late weeds such as green and yellow foxtail (pigeon grass) are bad, flax should be sown early so that it may become established before these warm-weather weeds get started. A good stand of early-sown flax is effective in the control of weeds, as is shown in figure 6.

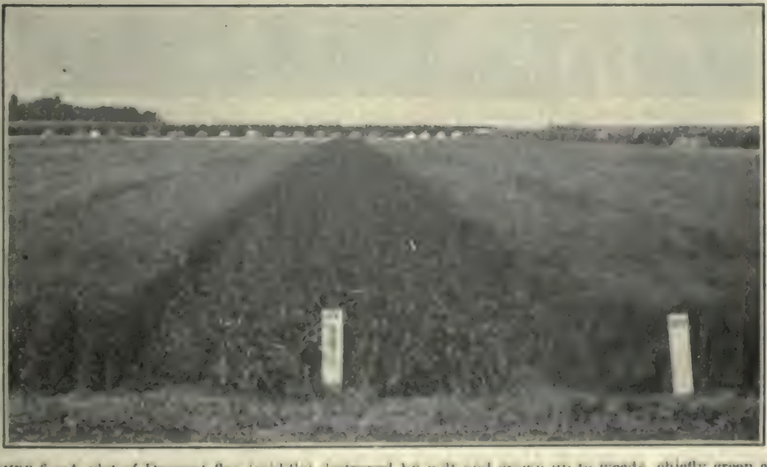

FIGURE 6.—A plot of Damont flax (middle) destroyed by wilt and grown up to weeds, chiefly green and yellow foxtail. The wilt-resistant varieties on each side have maintained good stands, which checked the growth of weeds. Photographed July 30 at the North Dakota Agricultural Experiment Station.

RATE OF SEEDING

In Montana and the Dakotas the usual rate of seeding for flax is 2 pecks (28 pounds) an acre, while in eastern Minnesota, where the rainfall is greater, it is considered an advantage to seed 3 pecks (42 pounds). The heavier rate of seeding insures a fuller stand and may help to control weeds. Under irrigation, flax usually is sown at the rate of fully 3 pecks an acre.

The rates of seeding mentioned are recommended for Bison flax, which has medium-sized seeds. If a small-seeded variety is grown, the rate may be slightly reduced, whereas for a larger-seeded type, such as Argentine, the rate probably should be somewhat increased.

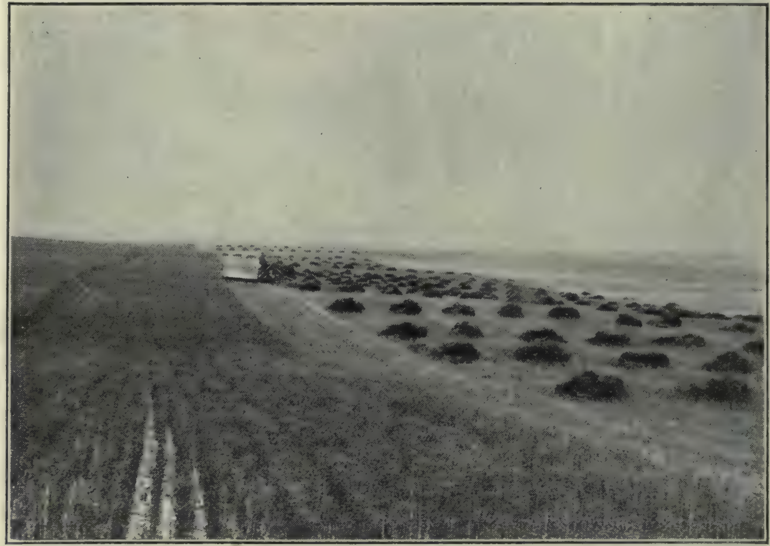

FIGURE 7.—Seed flax being harvested with a grain binder and put up in narrow shocks to dry.

HARVESTING

The flax plants should be fully ripe when cut, unless unusual conditions make this impracticable. Fully ripe flax will dry quickly in the shock or bunch. If sown late, or if the fall season is wet and cool, flax may continue to bloom until frost. Under these conditions it may be advisable to cut the crop when a large proportion of the bolls are ripe, even though the stems are still green.

Flax generally is cut with a grain binder. By proper adjustment, bundles of fair size and shape can be made. When flax cut with a binder is shocked the bolls are kept from the damp ground and the seed is not damaged. Small shocks should be made so as to allow ventilation through the center, or the bundles should be placed in long shocks only two bundles wide (fig. 7).

In the drier area flax sometimes is cut with a header or a reaper. The use of the reaper or the header saves the expense of twine and the labor of shocking. The small loose bunches dropped by a reaper or by a header with buncher attachment dry out rapidly in clear weather. Following a heavy rain, however, the bunches should be turned to dry; otherwise much seed will be damaged.

The cost of harvesting flax has been materially reduced by the use of the combine. Three more or less distinct methods of combine harvesting—windrowing, direct combining, or delayed harvesting—can be used, depending upon the condition of the crop.

If the flax crop is weedy, the use of the windrower is recommended. In dry weather, a few days after cutting, the windrowed flax will be in condition to thresh. Occasionally there is some difficulty in picking up windrowed flax if it settles down in weedy fields. To avoid this it is desirable to thresh the crop as soon as it is dry. In certain years flax does not ripen readily because of damp, cool weather, and in such seasons the use of the windrower is necessary. The windrower method is very generally used in harvesting flax on farms where the combine is available. It is cheaper than binding and is fully as satisfactory. The operation of the windrower costs about 50 cents an acre.

When the crop is free from weeds and has ripened uniformly, direct combining is the cheapest method and under favorable conditions is entirely satisfactory. Direct combining should not be attempted unless the flax is thoroughly dry and free of weeds.

In Montana and North Dakota harvesting sometimes is delayed until frost has killed the weeds. The weeds dry up rapidly after being frozen, and the flax can be harvested with a combine in a few days after frost. Ordinarily, flax will stand for a considerable time after ripening without loss from shattering. In very dry, hot weather, however, it may shatter somewhat, and therefore delayed harvesting can be recommended only when late flax does not need to stand too long before frost.

The combine or the windrower can often be used to harvest flax that is too short to be cut with a grain binder. This advantage in the use of the combine, however, does not justify the growing of short varieties of flax that are more difficult to harvest by all methods.

ROTATION

Formerly the bulk of the flax crop was raised on newly broken sod Flax is well adapted to growing on prairie sod while the sod is rotting It has the further advantage of being a quick-growing crop, requiring generally from 90 to 110 days from seeding to ripening. In the northern Great Plains flax can be sown as late as the first week of June with fair assurance of ripening, although early seeding generally is to be recommended.

Flax grown in rotation on old land should follow a crop that will free the land of weeds and leave a firm seed bed. A good rotation for flax is one that includes a legume crop such as sweetclover, red clover, soybeans, field peas, or alfalfa, followed by a cultivated crop like corn. Such a rotation should provide a fertile soil, clean land, and a firm seed bed.

Experience and experiments both indicate that flax does well when it follows corn. Where cultivation has kept the weeds under control, flax following corn has invariably given satisfactory yields in the flax-growing area. The usual practice is to sow the flax in the corn stubble without plowing. Where there is sufficient moisture and care is taken in the preparation of the seed bed, flax may also be grown following a legume crop. In rotation experiments at Fargo, in eastern North Dakota, flax has yielded better following red clover than following sweetclover, timothy, or alfalfa. In these tests the clover, alfalfa, or timothy was cut for hay, and the land was fall-plowed. Alfalfa growing on the land for several years depletes the supply of soil moisture. Therefore, flax crops following alfalfa were usually injured by drought in years of low rainfall. Sweetclover, like alfalfa, is a heavy user of water and leaves the soil very dry. The succeeding crop is therefore dependent on a fairly constant and generous supply of summer rain. Under conditions of limited or uncertain rainfall it would be preferable to have flax follow corn. If desired, the corn may be preceded by a legume crop or a legume-grass mixed crop in the rotation.

Experiments carried on by the Minnesota Agricultural Experiment Station, in which flax in 1923 followed several crops that had been grown for 2 years in succession (1921 and 1922) on the same plots, gave interesting results. Arny [2] says:

> The results from this work indicate that flax following corn produced the best crop. Flax following red clover, sweet clover, soybeans, and field peas was nearly as good as that following corn. Flax following wheat, oats, barley, rye, buckwheat, and flax was second rate as compared with that following corn, and flax following millet and sorghum was practically a failure. Flax following timothy was third rate.

It is a common observation that flax does poorly after timothy, redtop, or other grass crops, which appear to exhaust the available nitrogen that flax requires. Moreover, tame-grass sod is likely to be loose, as it does not pack readily to form a firm seed bed; whereas prairie sod, with its store of humus, rots readily and forms a firm seed bed.

CONTROL OF WEEDS

Because the flax plant is a poor weed fighter, it should be grown on the cleanest land available. Newly turned sod of prairie, pasture, and meadow lands having clover or other legume and clean corn stubble are best for flax.

Where old ground is used, every effort should be made to get rid of weeds and weed seeds before seeding. It often is an advantage to disk the land early in the spring to help start the growth of weeds. After 10 days this land may be disked or cultivated again to destroy the sprouting weeds. If there are many unsprouted weed seeds in the soil it may be advisable to delay seeding for still another 10 days in order to allow these to germinate and make possible their destruction by further cultivation just before seeding. Early-sown flax is preferable to late-sown flax; therefore delayed seeding, with cultivation, should be regarded mainly as a means to reduce weed competition. The object is to destroy weeds and weed seeds and still sow the flax as early as possible.

Control practices will vary to some extent with the kind of weeds. Where late weeds such as green and yellow foxtail (pigeon grass) are troublesome, flax preferably should be sown early, so that it may become well established before these weeds begin growth. Early-sown flax usually will ripen before green foxtail, and the immature weed seeds may be separated from the flax in recleaning by the use of a strong air blast.

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[2] ARNY, A. C. GROWING FLAX AS A REGULAR FARM CROP. Oil, Paint and Drug Reporter. 104 (20): 49. 1923.

Ordinarily, flax does not do well on loose soils following potatoes, especially on old lands that are likely to be foul with weed seeds. Since in the usual potato-digging operations buried weed seeds are brought to the surface, where they germinate readily the following spring, it generally is better to follow potatoes with a more vigorously growing crop. Moreover, the loose soils of potato fields are not very desirable for flax unless well firmed before sowing.

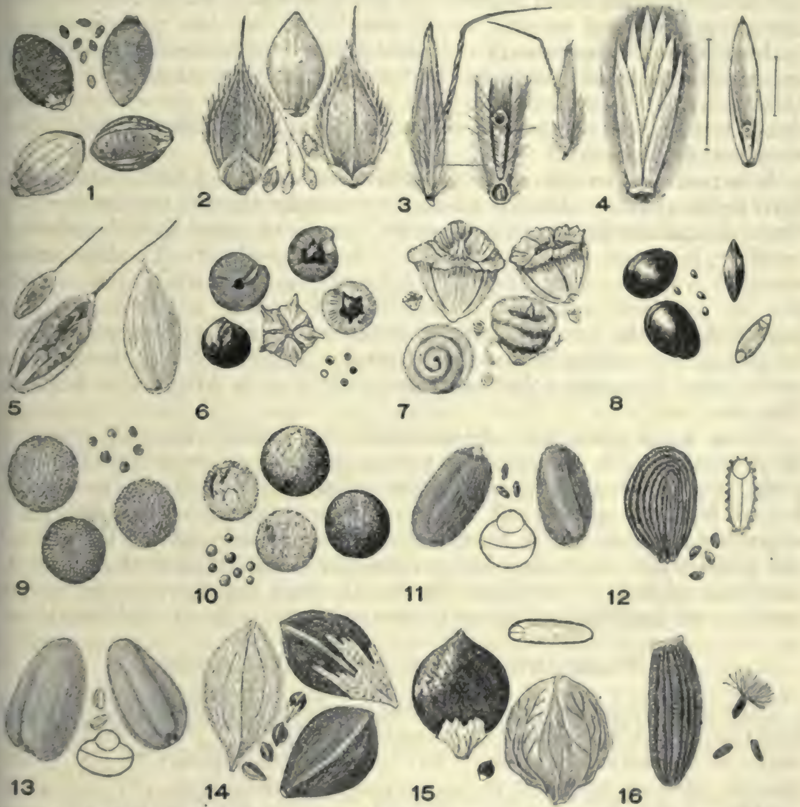

FIGURE 8.—Seeds of common weeds found in flax fields in Minnesota and the Dakotas: 1, Green bristlegrass (*Setaria viridis*); 2, barnyard grass (*Echinochloa crusgalli*); 3, wild oats (*Avena fatua*); 4, quackgrass (*Agropyron repens*); 5, darnel (*Lolium temulentum*); 6, lambsquarters (*Chenopodium album*); 7, Russian-thistle (*Salsola pestifer*); 8, redroot pigweed (*Amaranthus retroflexus*); 9, Indian mustard (*Brassica juncea*); 10, wild mustard (*Brassica arvensis*); 11, hares-ear mustard (*Conringia orientalis*); 12, French weed (*Thlaspi arvense*); 13, falseflax (*Camelina sativa*); 14, wild buckwheat (*Polygonum convolvulus*); 15, Pennsylvania smartweed (*Polygonum pensylvanicum*); 16, perennial sowthistle (*Sonchus arvensis*). Natural size and enlarged. Drawings by F. H. Hillman.

In the northern Great Plains, flax after summer-fallow is not always successful, although the reserve moisture supply in a well-kept summer-fallow is very beneficial to the succeeding crop. Even if weeds are kept under control during the season of summer-fallow, there is no assurance that such a field will be free from weeds. Russian-thistles and other weeds blown in from nearby fields during the fall and winter may reseed an otherwise clean seed bed. Wheat, a more vigorous crop than flax, is commonly grown on summer-fallowed land.

In semihumid areas where alfalfa, clover, or grass is included in the rotation, flax can be used successfully as a nurse crop. Since it does not produce dense shade, it makes a better nurse crop than do the cereal crops, which produce a ranker growth.

Where Russian-thistles are troublesome, as in the drier parts of the flax-producing area, it often is an advantage to disk corn stubble about 2 weeks before seeding and again just before seeding. The first cultivation aerates and warms the soil and starts the germination of innumerable weed seeds, which are killed by the second tillage. Indeed it may be necessary only to harrow for the second cultivation in order to kill sprouting weeds and put the soil in good tilth. Russian-thistles are at their best in dry seasons, and as they grow rapidly and draw heavily on the soil moisture, flax cannot do well where these weeds are numerous.

It is not easy to eliminate or control weeds in flax fields, and therefore fields that are known to be very weedy should not be sown to flax. Some weeds, as already stated, can be checked by tillage before seeding; however, this causes some delay in seeding. The late warm-weather weeds can be controlled by early seeding, which permits the flax to get well established before such weeds begin growth. A knowledge of the growth habits of different weeds is of first importance in planning a proper method of control. In figure 8 are shown weed seeds that are most commonly found in flax in Minnesota and the Dakotas.

These weed seeds are objectionable in flaxseed because many of them absorb oil in the crushing process and therefore reduce the total yield of oil. Mustard seeds, on the other hand, yield oil in crushing, but it is not a drying oil. If present in large quantity this oil is objectionable because it lowers the drying quality of the linseed oil. All these weed seeds should be removed from flaxseed that is to be used for seeding. Perennial sowthistle and quackgrass are serious weed pests and flaxseed should be carefully examined to avoid them.

FLAX AND WHEAT AS A MIXED CROP

Flax in mixture with spring wheat is grown to some extent in Goodhue County, Minn., and the surrounding district. The chief advantages of the mixed crop over flax grown alone appear to be (1) the greater ease of handling in harvesting and threshing, (2) the better control of weeds, and (3) a possible greater total return per acre. An average increase in yield of from 5 to 10 percent may be expected from the mixed crop under favorable growing conditions; that is, 2 acres of the mixed crop should produce on an average from 5 to 10 percent more grain than 1 acre of wheat and 1 acre of flax.

Weeds are controlled to a greater extent in the mixed crop than in flax alone. The partial shading effect and the taller growth of the wheat plants help to hold weeds in check. Wild oats, however, appear to grow as vigorously in the mixed crop as they do in either wheat or flax alone.

The mixed crop is sown at the usual date for seeding spring wheat. The usual rate of seeding in southeastern Minnesota is 25 to 40 pounds of flax with 2 or 3 pecks of wheat per acre. Somewhat less seed should be sown where the rainfall is lighter, as in the Dakotas. A thin stand of wheat is desirable; otherwise the yield of flax will be greatly reduced.

Flax sometimes is sown in fields of winter wheat where the stand has been thinned by winter-killing. This is successful if the fields are not too weedy. If weeds are numerous or the stand of wheat too thin, it probably would be best to disk or plow the field before seeding to flax or other crop. Peppergrass (*Lepidium*) and other annual winter weeds grow rapidly in badly winter-killed wheat fields and will choke out flax.

The mixed crop cannot be recommended where there is a ready sale for pure flax straw. Straw from the mixed crop has no value for manufacturing purposes but probably is fully as good as flax straw for feeding to livestock or for bedding. These facts should be considered in determining whether the mixed crop or flax alone is to be grown.

Another disadvantage of the mixed crop, especially where a large acreage is grown, is that the mixed grain must be separated before it is marketed. The separation usually is done with an ordinary fanning mill by using the proper sieves. A steel-wire sieve with meshes 4 by 16 to the inch is satisfactory for separating the small-seeded varieties of flax from wheat.

FLAX UNDER IRRIGATION

Flax is grown under irrigation only to a limited extent, although experiments indicate that it responds well to irrigation. It should be grown in a rotation that will free the land of weeds and maintain a high state of fertility, especially readily available nitrogen. At the Huntley (Mont.) Field Station flax has been grown in a 6-year rotation of alfalfa (3 years), corn, flax, and sugar beets. The alfalfa of the third season and the corn are pastured to pigs (hogged off), thus leaving the residue of two crops on the land. The average yield of flax for a period of 22 years has been 24.6 bushels an acre. The yield of sugar beets following flax has been high (an average of 15.6 tons an acre), indicating that flax has no injurious effect on the yield of sugar beets.

Yields of 20 to 40 bushels an acre have been obtained in varietal experiments at the Montana Agricultural Experiment Station at Bozeman, where conditions are favorable for flax. The crop was grown on clean summer-fallow and given only one irrigation at the beginning of the blossoming period. Possibly such high yields cannot be expected on a farm scale, but they indicate that flax responds well to irrigation.

At Brooks, Alberta, Canada,[3] the water requirement of flax grown in field plots under irrigation in 1920 and 1921 was determined. The use of 0.85 acre-foot of water applied in 4-inch irrigations was required to produce a 10-bushel acre yield of flax; 1.1 acre-feet produced 15 bushels; 1.25 acre-feet produced 18.5 bushels; 1.3 acre-feet produced 20 bushels; and a maximum yield of 21.5 bushels per acre required 1.34 acre-feet of water.

Since flax is a comparatively shallow-rooted crop, it responds better to light irrigations. This is illustrated by the fact that it required 5½ acre-inches more water to produce 18.5 bushels per acre in 6-inch than in 4-inch irrigations.

Under irrigation, flax usually is sown at a rate of 45 pounds per acre. It is desirable to seed early, so that the crop may have a long growing season. When the crop begins to ripen it is desirable to withhold irrigation in order to hasten maturity; if the soil is kep wet, blooming may continue indefinitely.

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[3] Irrigation Practice and Water Requirements for Crops in Alberta. Canada Dept. Int., Reclam. Serv., Irrig. Ser. Bull. 6. 1922.

CLEANING AND STORING THE SEED

Hundreds of cars of flaxseed are shipped to market that contai from 10 to 40 percent of dockage. This dockage often consists o cracked flax, weed seeds, and grain, which are valuable for feeding These should be screened from the flaxseed and ground and fed o the farm, since the grower receives little or no pay when they ar marketed as dockage. Screenings should be finely ground so tha weed seeds will not be scattered about the farm.

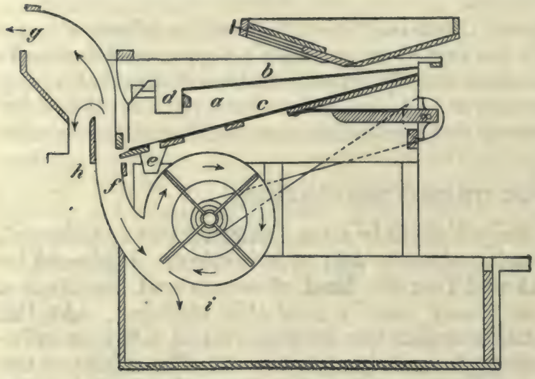

FIGURE 9.—A good type of grain-cleaning mill that will reclean flax for seed and separate the mixed grain, flax, and wheat: *a*, Shoe, carrying upper (*b*) and lower (*c*) screens; the shoe is given an end shake by means of an eccentric bearing operated by the crank shaft. *d*, Spout which carries off coarse material separated by the upper sieve (*b*); an upper sieve with meshes 4 by 16 per inch will separate wheat from flax. *e*, Screening spout which receives small weed seeds separated by the lower sieve. *f*, An air current driven up through the falling grain carries off chaff and dust through the hood (*g*); light seeds fall through the open space (*h*). *i*, Grain box, which receives clean grain; cone pulleys on the fan and drive shafts make it possible to drive the fan at any speed necessary to remove light seeds and trash.

Flaxseed should b thoroughly reclean with a good fannin mill before sowing. good type of farm fanning mill is shown i figure 9. Two principles are operative i cleaning the seed i this type of mill: (1 Separation by sieve according to size, an (2) separation according to weight. Th seed falls through strong air blast whic blows out the lighte seeds. A steel-wir sieve with meshes 4 b 16 per inch (or 4 b 14 for large-seeded varieties) will separat grain and the large weed seeds from flax A metal sieve with round holes one-fourteenth of an inch in diamete will separate small weed seeds. The air blast should be regulated s as to blow out all immature and cracked flaxseeds and trash.

Flax intended for seed should be recleaned before being stored and only dry, sound, plump seed should be saved. This will reduc the development of wilt, rust, and other diseases that may be carrie as spores on the broken stems, chaff, and immature seeds. Flaxsee should be dry and should be stored only in a dry place. Air-dr flaxseed contains only 6 to 8 percent of moisture, depending upon th humidity of the atmosphere.

DISEASES OF FLAX

The principal diseases of flax are wilt, rust, heat canker, an pasmo.

WILT

Wilt is a fungus disease that may attack flax plants at all stage of growth, causing them to wilt and die. It grows upon the liv plant and upon the dead roots and stems in the soil. When onc introduced, therefore, it may remain in the soil for an indefinit period. Figure 10 shows the first appearance of wilt in a field fre quently cropped to flax. In many cases such spots of wilt appear in the second or third crop. Authentic cases are known where a crop of flax was grown on new land without noticeable loss from wilt, but on the same land 5 years later the crop was entirely destroyed by wilt. The fungus apparently was introduced into the soil with seed for the first crop and increased during the 5-year period until it was widely distributed throughout the soil.

Wilt usually is introduced into a clean soil by sowing infected seed, although wind-blown soil and trash or run-off water from infected fields may carry the wilt fungus to new lands.

The use of mature, well-cleaned seed and the treatment of the seed with a copper carbonate or some other good dust fungicide should prevent or at least delay the introduction and spread of the flax wilt fungus to new lands. Although it is very desirable to prevent the introduction of wilt on new land as long as possible, the most practicable method of control is to grow a wilt-resistant variety (fig. 11). The wilt-resistant varieties Bison, Buda, Linota, and Redwing are generally grown.

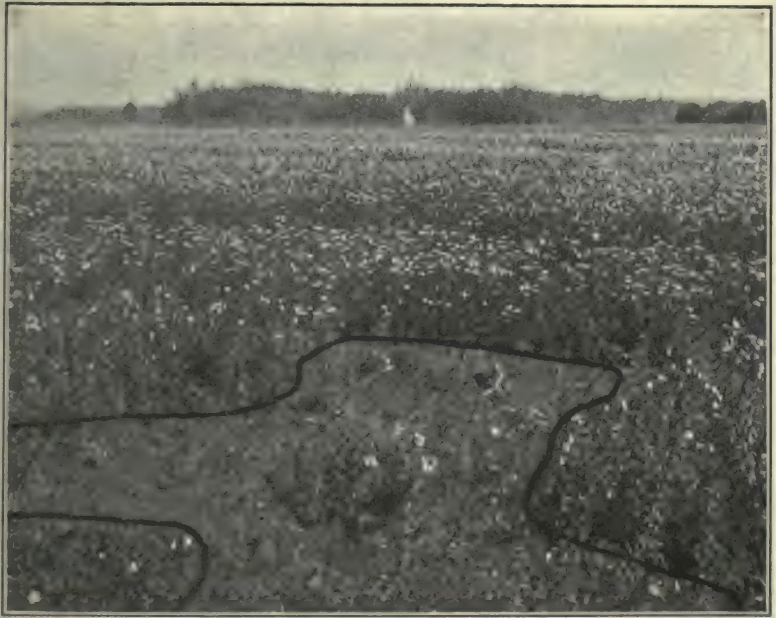

FIGURE 10.—A field frequently cropped to flax, showing the first appearance of flax wilt in spots. A wilt-resistant variety such as Bison can be grown on such land without loss from wilt.

RUST

In wet seasons or on low, damp soils rust may do considerable damage to flax, especially if the crop is late in ripening. The disease appears as bright orange pustules on the leaves and green stems. Later in the season the spots turn darker because of the appearance of the brownish spores that overwinter on the straw. As new infection comes from the old straw and stubble of the previous year, a rotation that avoids putting flax on the same land 2 years in succession will help to control this disease. A few varieties are immune from rust. These include most strains of Argentine, a few strains of Indian, Newland (C. I.[4] 188), Ottawa 770B (C. I. 355), Cirrus (C. I. 727), a fiber flax, and a group of hybrid strains produced at the University of Minnesota. The most promising method of control appears to be the breeding of varieties resistant to both wilt and rust. Bison, Buda, and Redwing are rarely injured by rust, although they are not immune.

HEAT CANKER

Heat canker is caused by high temperature at the surface of the soil and usually occurs when the plants are from 2 to 6 inches high. It is most destructive on soils that have been compacted by rain. The stems are girdled and the plants break over. Some plants may continue to grow for a time, but ultimately they break off in the wind. The best control measure appears to be early seeding at a rate sufficient to insure a full stand. This enables the plants to become large enough to shade the ground somewhat before the hot weather of late June and early July.

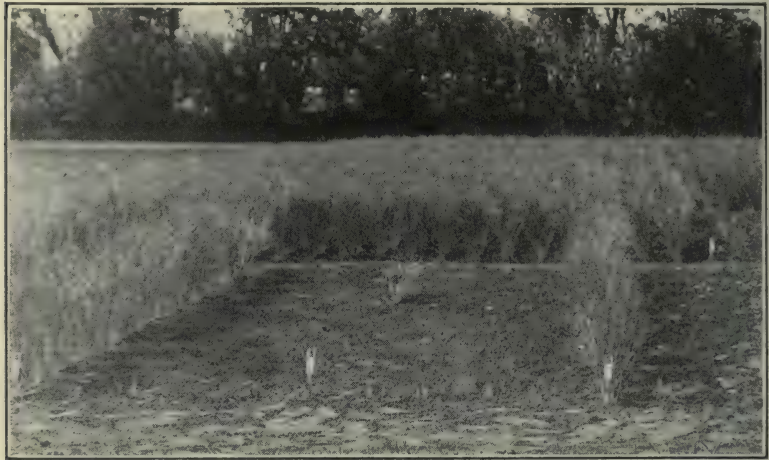

FIGURE 11.—A flax-breeding nursery showing the wilt resistance of selected strains of flax in contrast to the total loss of susceptible varieties. Photograph taken on "flax-sick" soil at the North Dakota Agricultural Experiment Station.

PASMO

Pasmo first appears as yellow-brown circular lesions on the seed leaves (cotyledons) and foliage of young flax plants. However, it is most readily recognized on the flax stems in the early ripening stage as irregular bands of brown mottling alternating with bands of green. It is not known how much damage pasmo causes. Fair yields of seed are obtained when the disease appears to be prevalent. It probably does more damage to fiber flax than to seed flax. Argentine varieties appear to be more susceptible to the disease than others. Pasmo is known to be carried on the seed; the introduction of infected seed into new territory should be avoided so far as possible.

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[4] C. I. denotes accession number of the Division of Cereal Crops and Diseases.

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U. S. DEPARTMENT OF AGRICULTURE
FARMERS' BULLETIN No. 1748

GINNING COTTON

IMPROVED PRACTICES in handling and ginning seed cotton will result in improved quality in the ginned lint and relatively better prices to the cotton farmers. It is the responsibility of the farmer to deliver cotton to the gin in the best possible condition, and it is incumbent on the ginner to see that the quality of the lint is not lowered by improper ginning methods. The moisture content of seed cotton is an important consideration in good ginning; if it is too high the cotton should be artificially dried before being ginned.

The development of commercial cotton-ginning plants, utilizing somewhat costly machinery of large capacity in order to do the work cheaply, has emphasized the importance of speed in ginning. As a result, the ginners have had a tendency to gin each load of cotton as rapidly as possible in order to get the largest return on their investment in equipment, and in this they have been encouraged by the farmers, who wish to wait no longer than necessary to have their cotton lint and seed ready for sale. In the effort to gin quickly, the quality of much of the American cotton has been injured.

That the good qualities in the cotton brought to the ginning plant can be preserved by proper ginning equipment and methods has been demonstrated at the Department's cotton-ginning and fiber laboratories, and the increase in cost of such service over more hasty ginning is less than the increase in value of the lint. This bulletin discusses methods and equipment for handling and processing seed cotton from the time of harvesting until the lint is baled so as best to retain the desirable qualities of the fibers.

This bulletin supersedes Farmers' Bulletin 1465, Cotton Ginning.

Washington, D. C. **Issued August 1935**

GINNING COTTON

By Charles A. Bennett, *senior mechanical engineer, Bureau of Agricultural Engineering*, and F. L. Gerdes, *associate cotton technologist, Division of Cotton Marketing, Bureau of Agricultural Economics* [1]

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INTRODUCTION

Cotton ginning includes the cleaning and other preliminary processes involved in preparing seed cotton, as well as the separating of the fibers from the seed. When harvested, cotton usually contains dirt, hulls, leaf fragments, and other material which must be removed if the ginned lint is to have the highest market value.

With present-day gin machinery it is not possible to produce from roughly harvested seed cotton lint equal in quality to lint from carefully picked cotton. Therefore, a farmer should see that all his cotton is picked as carefully as possible.

Cotton farmers, as well as others connected with the cotton industry, benefit from good ginning and suffer from poor ginning. Manufacturers will not knowingly pay cotton prices for moisture, dirt, and so forth, nor will the market absorb poorly ginned, rough, or damp lint unless the price is reduced. Each person connected with the various channels through which cotton passes tries to protect himself, and ultimately, in dollars and cents, the cotton grower bears the brunt of every penalty.

HOW FARMERS CAN HELP TO IMPROVE GINNING

Cotton farmers can promote good ginning by furnishing the ginner with cotton in good ginning condition. They can also demand that the ginner employ those ginning methods that will best preserve lint quality. Such action should make it possible to obtain a higher price in the local market, and, combined with cooperative efforts, to promote a greater utilization of cotton through new uses and an extension of present uses.

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[1] Acknowledgment is due the following manufacturers of ginning machinery for their courteous and helpful assistance: Continental Gin Co., Gullett Gin Co., Lummus Cotton Gin Co., The John E. Mitchell Co., The Murray Co., The Boardman Co., and The Phelps Co.

Tests conducted by Department workers show that excessive moisture in seed cotton markedly reduces the quality of the lint and makes it difficult to sell without the severe penalties that sometimes amount to 25 percent of the possible value of the bale. If the cotton is too moist because of greenness or exposure to rain or dew, in clear weather it may be spread on sacks, tarpaulins, racks, or galleries and exposed to the sun. Care must be taken to keep it from getting wet again. Such drying involves a great deal of work and is expensive. A Philbrick drier (fig. 1) may be used, consisting of screen-bottomed trays on racks, and a shed in which to stack the trays in bad weather. The first cost is several hundred dollars. This drier has only a limited capacity and cannot be used in wet weather.

The period of exposure to the sun necessary to insure improved ginning depends on the moisture content of the cotton, the depth of the layers, the temperature and relative humidity of the atmosphere, the number of times the cotton is turned or aired, the staple length of the cotton, and other factors. The cotton should be exposed in layers from about 4 to 8 inches in depth to obtain effective sun-drying by any method. If the cotton is very green or wet it should be exposed from 15 to 20 hours. If it is only slightly green, damp, or dew-laden, drying for 7 to 15 hours is usually enough. Except when placed in screen-bottomed trays, the cotton should be turned or aired occasionally during exposure to insure the uniform drying of all locks. These periods of exposure may be somewhat less for short-staple than for long-staple cotton, because from a ginning standpoint a moisture content that is excessive for long cotton is not necessarily so for short cotton.

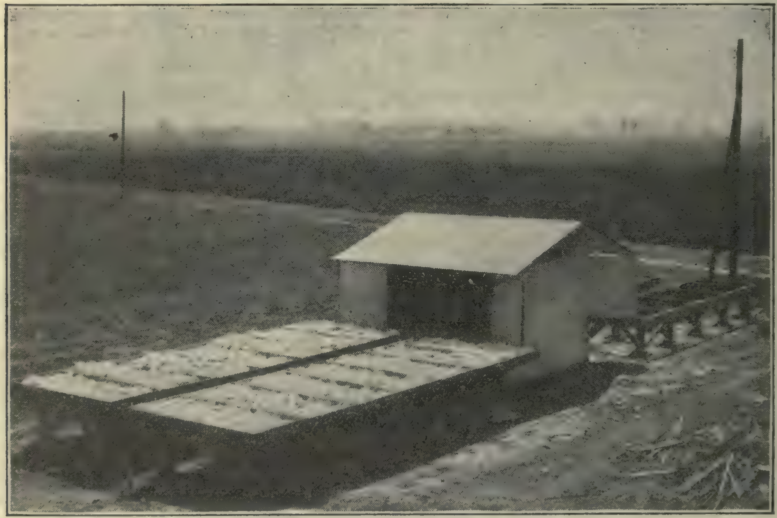

FIGURE 1.—Philbrick drier for seed cotton.

If it is not practicable to handle damp or wet seed cotton enough for satisfactory sun-drying, it is a good practice to at least sun-dry the morning dew-laden pickings. The afternoon pickings, which usually are drier, may be placed in the wagon or cotton house and the sun-dried morning pickings added to them at the end of the day.

It is a bad practice to place green, damp, or wet cotton with dry cotton in a wagon and take it to the gin immediately. The side of the bale containing the cotton with excessive moisture will be lower in quality than the side ginned from the drier cotton, and the value of the bale will be determined on the basis of its low-quality side.

Storing green, damp, or moderately wet seed cotton on the farm before ginning generally improves the quality of the ginned lint, if the cotton is turned and aired during storage. If it is not turned and aired, especially if it is wet, there is danger that it will "heat" to such an extent that the quality of lint will be lowered as well as the germinating and milling qualities of the seed.

The period of storage needed to dry cotton depends on the moisture content of the cotton, its staple length, its depth and compactness, the temperature and relative humidity of the atmosphere, the rate of air circulation, the number of times the cotton is turned and aired, and other factors. The cotton should be stored loosely and in as shallow piles as possible, 2 to 4 feet being the depth used by many farmers. If the weather is dry and hot, a period of 1 week is usually enough but the damper the weather the longer will be the storage period required. If the weather continues damp so long that the cotton is likely to deteriorate, it should be taken to a gin that has a mechanical drier. Storage of cotton before ginning is a questionable practice in damp regions. Damp or wet cottons should never be stored in the same bin with dry or normal-moisture-content cotton.

Where rains occur frequently during the cotton-picking season, as in the eastern part of the Cotton Belt, it is especially important that cotton be picked as soon as practicable after the bolls open. Cotton left in the field and exposed to such weather is discolored, is contaminated with soil, and is soil-stained, all of which lower the grade and character; if it is damp, it should be dried before being ginned.

Early pickings ordinarily should not be mixed with later pickings for ginning, as the later pickings are usually lower in quality and cause the lint of the entire bale to be sold at the price of the lower quality.

Tenant labor, living on the farm, generally will pick cotton better than will transient pickers, who are concerned principally with obtaining the most money for their labor. It has been observed that the lint ginned from cotton picked by farm labor was from 1 to 2 grades higher in quality than that from cotton picked by transient pickers in the same field on the same day. The lower grade was the result of greater proportions of burs, stems, partly opened and even green bolls, immature and weevil-damaged bolls, and dampness in the cotton picked by the transient labor.

MACHINERY AND PRACTICES AFFECTING GINNING

In order that benefits may result from improved handling of seed cotton by the grower, the ginners must help to preserve the inherent quality of cotton by adopting the very best ginning practices and methods. When this is done, the cotton farmers and others concerned should become adjusted to charges that are in keeping with the services rendered.

Before discussing some of the relationships between ginning machinery and lint quality, and ways by which the ginner may give the farmer a better service, it seems desirable to describe in general the processes used in ginning cotton, even though these may be familiar to many.[2]

In view of the fact that only a fraction of 1 percent of all the cotton-ginning plants in the United States are equipped with roller gins,[3] the discussion in this bulletin is confined to saw gins. In 1933, according to the Bureau of the Census, there were 13,543 active cotton gins in the United States.

COTTON-GINNING PROCESSES

The processes associated with ginning include the entire series of handling operations from harvesting the seed cotton to baling the ginned lint and disposing of the seed at the cotton-ginning plant. Figure 2 shows the processes that are available for ginning cotton, and indicates possible routes that the seed cotton may follow before the bale is wrapped and the seed is housed or returned to the farmer.

The ginner has a wide choice of machinery for preserving or improving the quality of the farmers' cotton. If the seed cotton is too green, damp, or wet to gin, the ginner can dry it in a drier before passing it to the cotton-gin telescope that carries it to either a separator or pneumatic elevator.

In case the gin is equipped with a mechanical system of feeding, the cotton may undergo a precleaning process which may involve the use of a drier, cleaners, and extractors. The advisability of using these machines depends on the condition of the cotton and whether it has previously been processed by a drier or an air-line cleaner. Following this special processing, the cotton is handled by a separator that discharges it to any or all of the prefeeding processes, which are similar to the special processes. Whether one of these is used depends upon the condition of the cotton and the use of previous equipment. Drying is usually accomplished at only one of these points, but cleaning and extracting may be done at all.

From the prefeeding processes of the mechanical system and the pneumatic elevator of the pneumatic system the cotton may be discharged to some one of the feeder units shown in figure 2, the selection of which should depend on the condition of the cotton and the treatment previously received. From the feeders the cotton passes to the gin stands, where the fiber is separated from the seed. The lint is discharged to the press through the customary routes and the seed to the seed hopper or seed house.

It may be seen that many different types and combinations of machinery may be used in ginning cotton, and it is advantageous for both the farmer and the ginner to know the effects of the different appliances on the quality of the ginned lint.

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[2] See also mimeographed reprint, Bureau of Agricultural Economics, Problems and Research Methods in Cotton Ginning.

[3] For information concerning roller gins the reader is referred to Department Bulletin 1319, Ginning Pima Cotton in Arizona.

DRIERS FOR SEED COTTON

Moisture in the seed cotton is one of the most important factors affecting gin operation and the quality of the ginned lint. Need for means of removing the excess moisture in order to promote good ginning is emphasized by the fact that generally weather conditions in the Cotton Belt, particularly east of the Mississippi River and in the Delta sections adjacent on the west, are such that a considerable portion of the crop is ginned in a green, damp, or wet condition, which interferes with good ginning.[4]

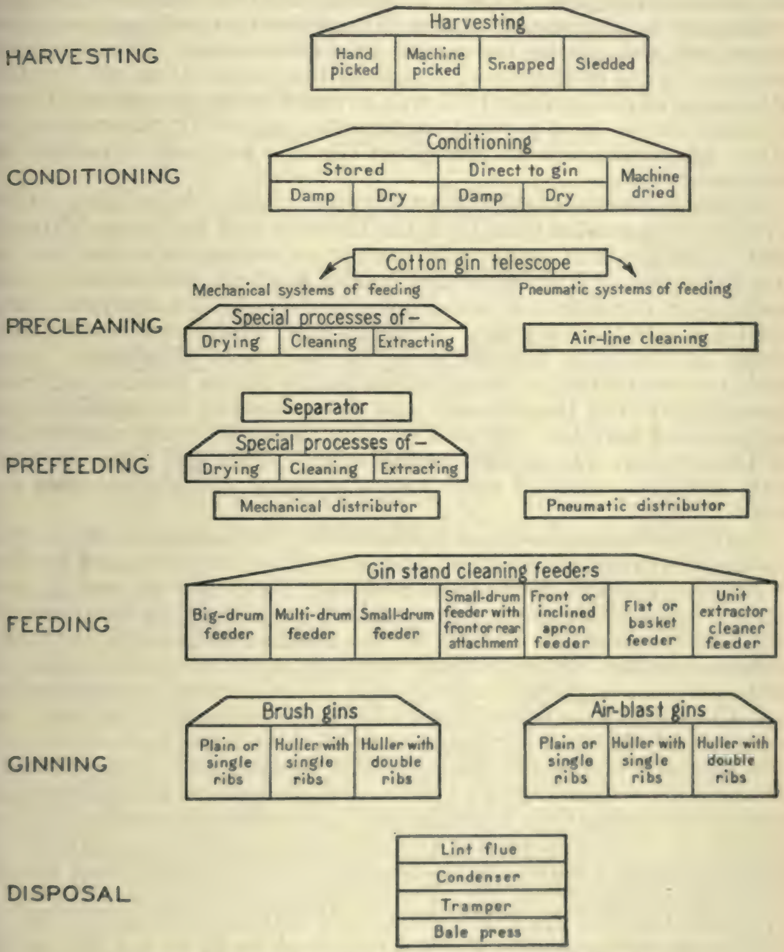

FIGURE 2.—Diagram of processes involved in the ginning of cotton.

Of the crop of 1932 more than a half million bales or about 35 percent of the cotton $1\frac{1}{16}$ inches and longer, and more than 2 million bales or about 20 percent of the cotton shorter than $1\frac{1}{16}$ inches, were green, damp, or wet and therefore not in condition to gin well. In 1931, a season of relatively low rainfall, 24 percent of the bales of the longer cotton and about 8 percent of the bales of the shorter cotton were too damp to give best ginning results. During the 10 years next preceding 1933 more of the cotton-ginning seasons corresponded in weather conditions to 1932 than to 1931. Even in a relatively dry season, much of the early harvested cotton is too damp to allow the best operation of ginning machinery and yield best quality of sample.

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[4] See Effect of Artificially Drying Seed Cotton Before Ginning on Certain Quality Elements of the Lint and Seed and on the Operation of the Gin Stand. (Unpublished manuscript.)

Moisture in seed cotton varies from section to section in a given season and also during the season in a given area. The estimated number of bales of the longer staple cotton ginned from seed cotton with excess of moisture in 1932 was as much as 40 percent in Mississippi and as low as 4 percent in Arizona; and of the shorter staple cotton, approximately 40 percent in Georgia and only 3 percent in Oklahoma.

Equipment for economically drying green, damp, or wet seed cotton at the gin is desirable from both the farmer's and the ginner's standpoints. Methods of reducing the moisture content of cotton on the farm have already been described, but as has been pointed out, those practices are cumbersome, entail considerable additional expense, and sometimes are not feasible. Processes and equipment to dry seed cotton artificially at the gin have therefore been developed. As a result the vertical drier [5] was devised in the cotton ginning and fiber laboratories of the Department, and the process of drying developed and patented between 1926 and 1928 by the agricultural engineers of the Department was applied to this drier. This and other types of driers and the process of drying were patented and dedicated to the public.

The Government design of vertical drier has horizontal floors (fig. 3) and different methods by which the damp seed cotton and the hot air can be delivered to the drying tower. There are no moving mechanical parts within the drying chamber, and after it has been warmed up for a few minutes it is ready for the continuous drying of as many as six bales of seed cotton per hour, which is as fast as cotton ordinarily can be ginned at a plant of average size. Satisfactory drying requires from 40 to 100 cubic feet of hot air for each pound of damp seed cotton, a period of exposure ranging from 15 seconds in the vertical drier to as long as 3 minutes in driers of other designs, and drying-air temperatures at or near 150° F. Because the fibers are much more susceptible to drying than are the seed, the relatively short period of exposure to the hot air puts the cotton into much better condition for ginning than the reduction in moisture content of the seed cotton indicates.

In operating the drier, the damp seed cotton is introduced into a continuous stream of hot air and conveyed by it to the top of the tower; then the cotton descends in a zigzag course from one floor to another, with repeated agitations against the warm walls which it strikes as it changes direction at each floor. In this manner the cotton is opened and fluffed up, and the drying is facilitated. Practically every lock of cotton receives the same treatment, and irregular feeding or large chunks of cotton are quickly spread out into a uniform and fluffy layer as the seed cotton descends through the tower. At the base of the tower, the striking of the cotton against the screen is remarkably cleaning, and the dried cotton then passes on to the ginning machinery.

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[5] Miscellaneous Publication 149, The Vertical Seed-Cotton Drier.

The vertical drier has proved to be one of the most practical and economical means of drying cotton. Operating costs range from 30 to 50 cents per bale. A practical installation is pictured in figure 4.

Tests with vertical driers have been made by the Department on numerous samples of cotton of different fiber lengths and of moisture contents ranging from less than 8 percent to more than 16 percent. The higher the moisture content of the seed cotton, the greater was the improvement shown in grade of lint, the less was the effect of the drier on staple length, and the greater was the moisture removal. As the drying temperatures were increased from 150° to 250° F., for a seed cotton of any given moisture content the grade of lint improved slightly; the staples were a little shorter because of the breaking of the fibers; and slightly more moisture was removed.

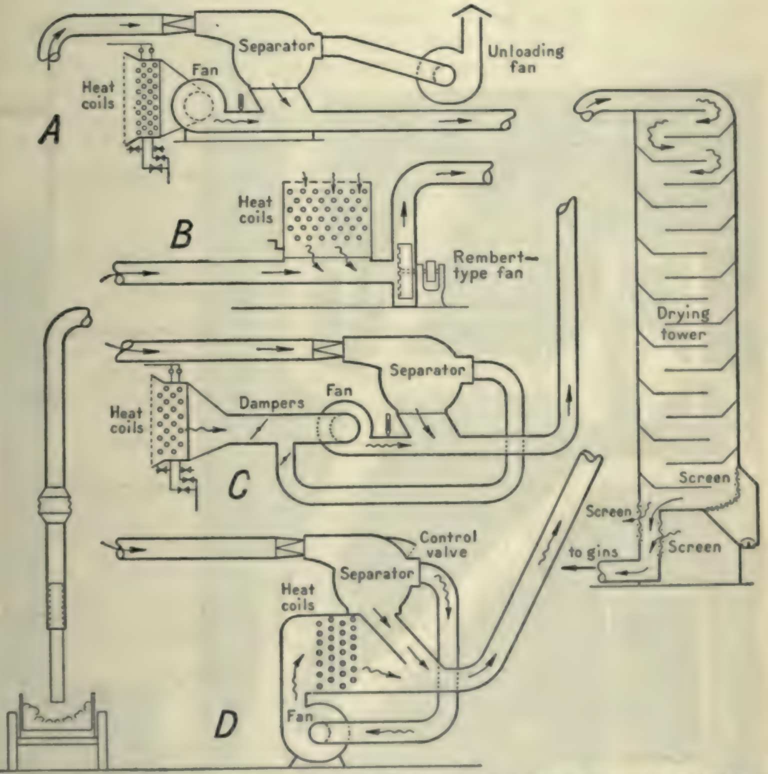

FIGURE 3.—Four methods of feeding vertical seed-cotton drier: *A*, Two fans and separator; *B*, single Rembert fan, split suction; *C*, single fan and separator, split suction; *D*, single fan and separator. Various types of blast-coil radiation may be used with *A*, *B*, and *C*, but only smooth iron-pipe coils with *D*.

Cotton 1⅛ inches and longer having less than 8-percent moisture content and cotton shorter than 1⅛ inches having less than 12-percent moisture content showed little or no net improvement in quality as a result of drying. With moisture content exceeding these limits, however, drying did improve the lint quality. A drying temperature of 150° F. gave the highest net benefit for each length group. Temperatures of 170° to 200° were used safely on very wet cottons, but temperatures higher than these are usually injurious to fiber length and other fiber properties.

Drying seed cotton at 150° F. improved the grade, on an average, from one-third of a grade for the longer staple cotton having 8.00 to 11.99 percent moisture and the shorter staple cotton having 12.00 to 15.99 percent moisture, to about one grade for both the longer and the shorter cotton having 16 percent and greater moisture content. Some of the individual samples of cotton having 16 percent and more moisture were so wet that drying improved the lint quality by about two full grades. For a group of 12 samples varying in length from

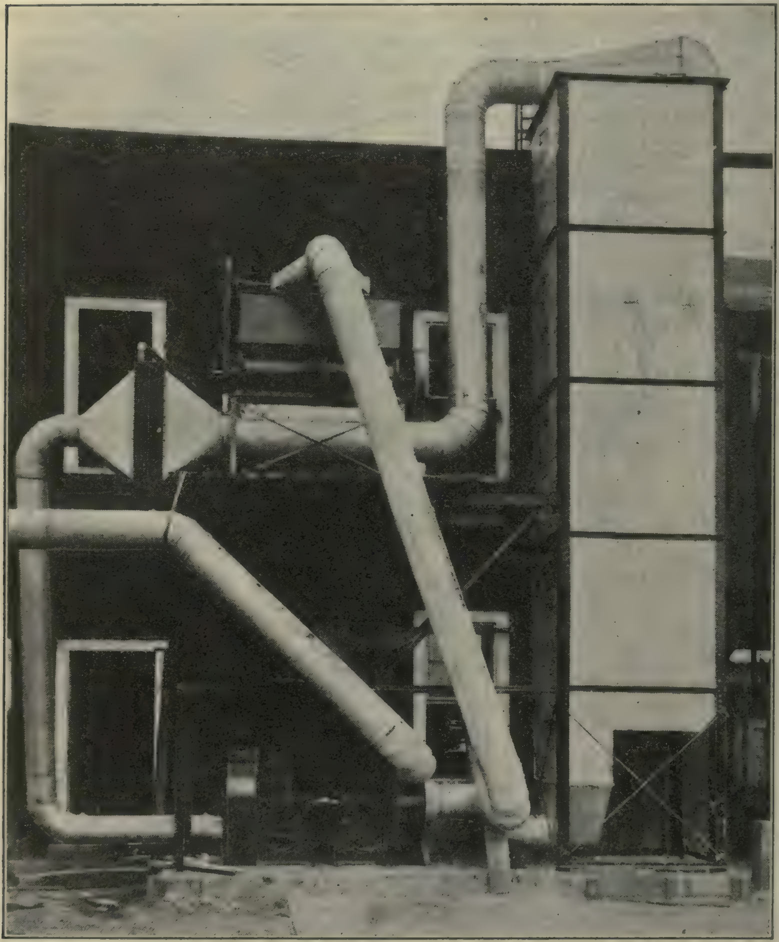

FIGURE 4.—A Government-designed factory-built vertical drier at an Arkansas cotton gin near the Mississippi River.

1⅛ to 1¼ inches, the quality of the lint was improved enough by drying to show, on an average, net benefits of about $2.50 per bale for the green, damp, or wet cotton having 12 percent or more moisture and of approximately $2 per bale for cotton of moisture content less than 12 percent.[6]

In a group of 11 samples of cotton varying in staple length from 15/16 inch to 1 3/32 inches, the damp or wet cotton showed net benefits from drying averaging about 70 cents per bale, whereas the drier cotton was reduced in value as a result of drying. These figures indicate that the longer the staple, the greater the increase in net value to be obtained by artificially drying damp or wet seed cotton.

Improvements in grade, particularly those made through preparation, for short-staple and long-staple wet cottons are shown in figures 5 and 6, respectively. The preparation improvements were enough to increase the classification by about one grade in each instance.

In addition to the quality benefits from drying, there are other advantages from both the farmer's and the ginner's standpoints. If cotton is to be dried, picking can be continued during damp or rainy seasons and in fields of heavy foliage, thus reducing weather damage to unpicked open bolls. As the gin operates at greater capacity with dried cotton, regardless of weather, the drying of green, damp, or wet cotton is important to the ginner. Drying also reduces power requirements as well as costly break-downs and chokages, and permits the cleaners, extractors, and feeders to operate more smoothly and more effectively. The ginner not only obtains a better capacity, but he can also preserve the lint quality. The germination and milling qualities of the seed are believed to be improved by drying.

COTTON HOUSES AT THE GIN

In some sections of the country it is usual to maintain seed-cotton storage houses near to and as part of the ginning establishments. Such cotton houses usually are constructed to provide (1) storage suitable for the natural conditioning of green, damp, or wet seed cotton, which must be turned from time to time or moved from bin to bin until it is in a condition suitable for ginning; (2) protection against bad weather, so that customers can unload their cotton quickly into individual bins and return to their farms without tiresome waits and exposure to rains or storms; (3) storage for one-variety crops, the seed of which is to be used for planting, when the customer wants to accumulate enough seed cotton to be ginned out in one lot without danger of its being mixed with other varieties; and (4) a temporary storing place for surplus seed cotton received during the day, so that it can be ginned by a night shift.

These cotton houses may be either rectangular or octagonal, and should have enough bins for usual requirements. The cotton can be placed in the bins by hand through the side windows, or mechanically by various systems. Cotton piping from an entry passage or hall in the house is provided so that stored cotton can be transferred by air directly to the gin. In rectangular cotton houses the Rembert type of fans are customarily used for unloading the seed cotton from the wagon and blowing it to the bin. Distribution to bins can be made by using a standard fan and separator combined, or by using a standard fan,

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[6] Calculations of value are based on the average commercial prices for cotton of the various grades and staple lengths prevailing at Memphis, Tenn., during the season 1932-33.

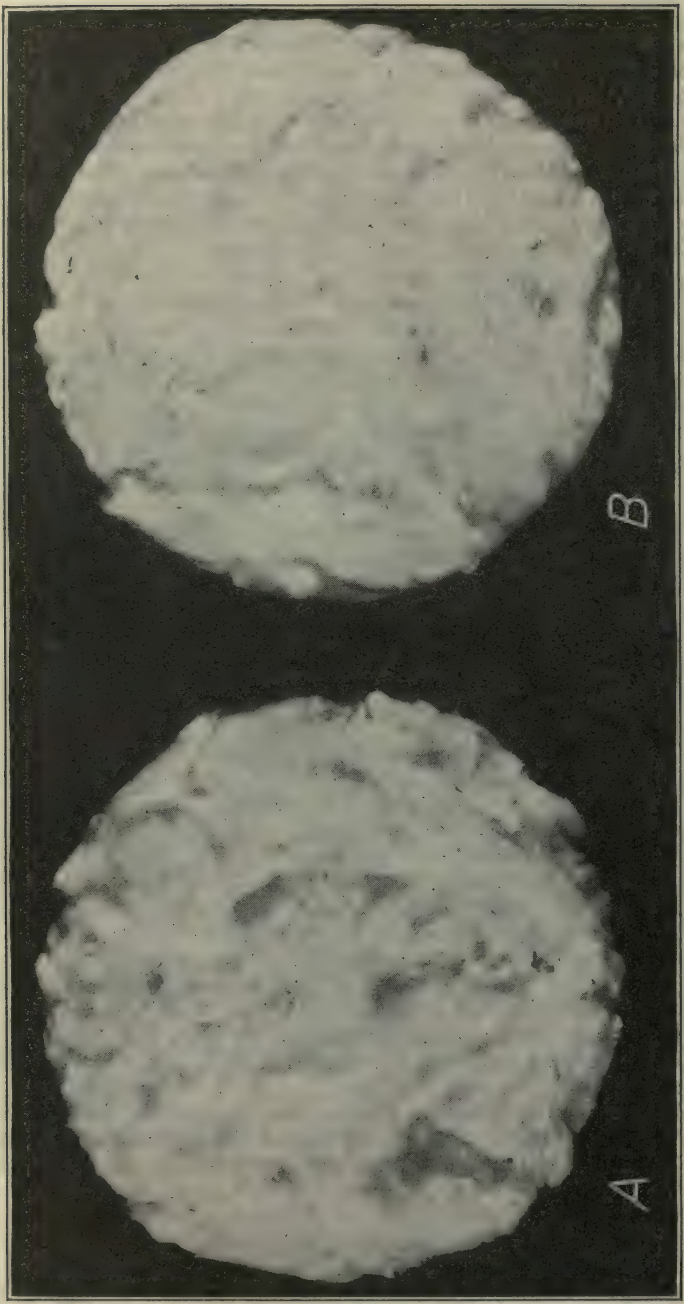

FIGURE 5.—Short-staple cotton ginned (*A*) from damp seed cotton and (*B*) from a portion of the same seed cotton after artificial drying.

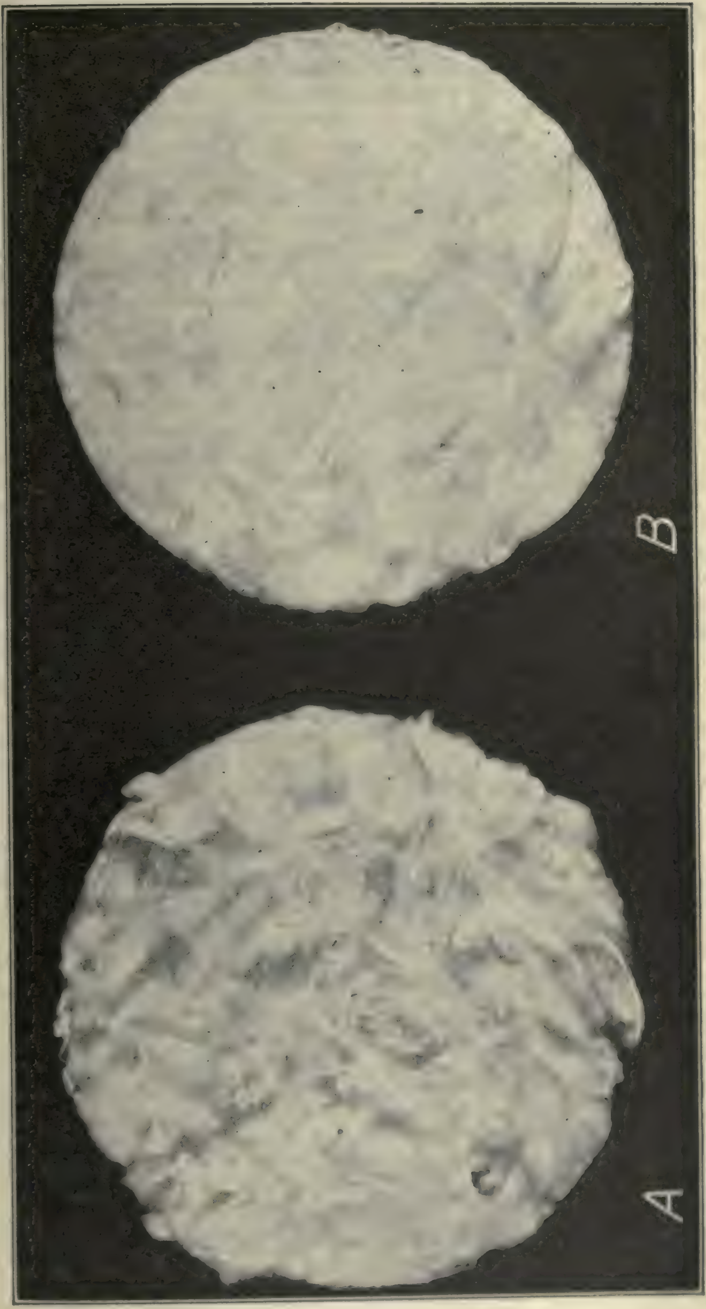

FIGURE 6.—Long-staple cotton ginned (*A*) from damp seed cotton and (*B*) from a portion of same seed cotton after artificial drying.

separator, and traveling belt fitted with gates for deflecting the seed cotton from the belt to the bin selected.

An octagonal cotton house, with the form of dropper ordinarily used for filling the bins by pneumatic means, is shown in figure 7. In such houses, the number of bins varies usually from 7 to 16, and the inclined chute beneath the dropper may be swung to discharge into any bin. The piping within the cotton house (shown by dotted lines) is a telescoping pivoted extension that reaches to the doorway of any bin and allows the cotton to be transferred to any other bin or to the cotton gin.

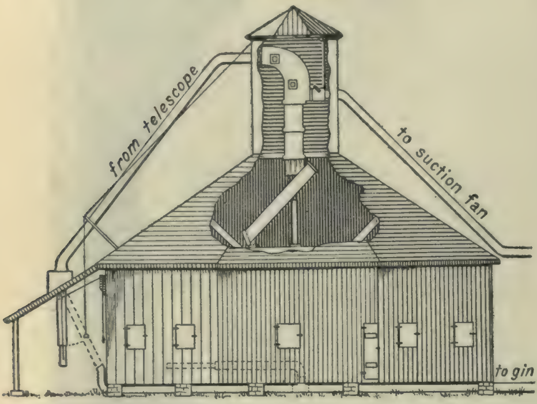

FIGURE 7.—Octagonal seed-cotton house, with pneumatic system for filling and emptying bins.

The bottom of the dropper is fitted with a canvas leg that draws together when the fan is exhausting, but when the fan suction is broken by operating the air valve the accumulated cotton drops by gravity through the canvas leg to the pivoted inclined chute. Thus the unloading of the wagon and the filling of the bins is intermittent, similar to the action of the pneumatic feeding system employed in cotton gins.

Cotton houses and seed houses should be made ratproof to prevent serious damages to their contents. It is best to do this work during the construction of the buildings, if possible.[7]

CLEANERS AND EXTRACTORS

Rough harvesting is responsible for intermingling with seed cotton portions of the cotton plants such as leaves, burs, and stems, and such foreign matter as sticks, weeds, and trash. Windstorms may fill the unharvested cotton with sand or dirt; rains and winds may together blow locks of cotton from the stalks into the mud; insects may damage the locks or seed; and cold weather may produce frost-bitten locks of cotton. In some sections cotton gins have been forced to handle as much as 3,000 pounds or more of material in order to gin out a 500-pound bale of lint, whereas 1,250 to 1,600 pounds of clean hand-picked seed cotton would provide a 500-pound bale of ginned lint. Using machines to remove this foreign material from the seed cotton at the gin with the least possible injury to the fiber is valuable in that it helps to maintain the grade of such cotton.

These machines are of two kinds, generally referred to as cleaners and extractors. Cleaning is the process of removing such small particles as sand, pin or pepper trash, and portions of shuck that can readily be passed through wire screens. Extracting is primarily the removal of large particles such as burs, sticks, stems, and whole leaves that cannot successfully be screened out, as well as the small particles removable by cleaners. Cleaning can be performed by extractors, but extracting cannot be performed by cleaners.

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[7] Farmers' Bulletin 1638, Rat Proofing Buildings and Premises, gives information on protection against rodents.

Cleaning and extracting processes, if properly used, are of far-reaching benefit to both farmers and ginners. These processes should not encourage a cotton farmer to adopt undesirable harvesting practices and methods but should be used to protect his crop against damage that would occur if his seed cotton were ginned without being cleaned and extracted. Cleaners and extractors are of great assistance to the ginner in protecting his gin stands from injury, by breaking up masses of packed or hard seed cotton and helping uniform feeding and handling.

As shown in figure 2, cleaning can be done in several positions between the wagon telescope and the distributors. Cleaners in those positions may appropriately be designated as master cleaners, to distinguish them from the small unit cleaners classified as gin-stand cleaning feeders. A master cleaner handles the entire volume of seed cotton passing through the system, whereas a unit cleaner handles only the cotton for one gin stand.

The cleaning screens in cleaners and extractors, if not checked both for condition and correct position, may be the cause of roughness, roping, and machining of the material. Broken screens are a frequent source of damage to the seed cotton. Screens too close to the cylinders may cause machining of the cotton and if too far away may produce roping and rolling.

The cylinders in cleaners and extractors often receive severe abuse from foreign matter, particularly rocks and sticks. Consequently the spikes, blades, or teeth of these cylinders require periodical alignment and straightening.

Elaborate processes of drying, cleaning, and extracting are frequently found in the precleaning position of some gins, and in the prefeeding position of others. It is not common practice to use them in both positions. Pneumatic systems are seldom found where the cotton is snapped, sledded, or machine-picked because the intermittent functioning of pneumatic systems generally makes impracticable any cleaning except that which may be obtained from air-line cleaners and from gin-stand cleaning feeders.

The inventions of equipment for handling seed cotton through piping by means of fans have been important factors in the improvement of ginning machinery and have led to the development of two types of cleaners which are technically known as "air-line" cleaners and "out-of-the-air" cleaners. Usually, unless cleaners are specifically referred to as air-line cleaners, it is understood that they are of the out-of-the-air type. The general construction of the two types is similar, but the air-line cleaners must be air-tight because they are connected with the suction piping of the ginning plant and leaks in the cleaner therefore would tend to prevent satisfactory movement of the seed cotton.

AIR-LINE CLEANERS

Air-line cleaners are designed to reduce the velocity of the air currents within the body of the cleaner so that agitation of the cotton locks will shake out foreign matter and allow it to fall through a screening surface and then be discharged or trapped. Figure 8 shows diagrammatically the general forms of air-line cleaners. The axial-flow or single-cylinder type (fig. 8, *A*) has a cylindrical screen within the cleaner casing, and long paddles on a shaft passing through the center of the cylinder, the tips of the paddles having a moderate clearance with the screen. These paddles act as openers and beaters to break up wads of seed cotton into locks and agitate the cotton as it travels through the cylinder to the outlet.

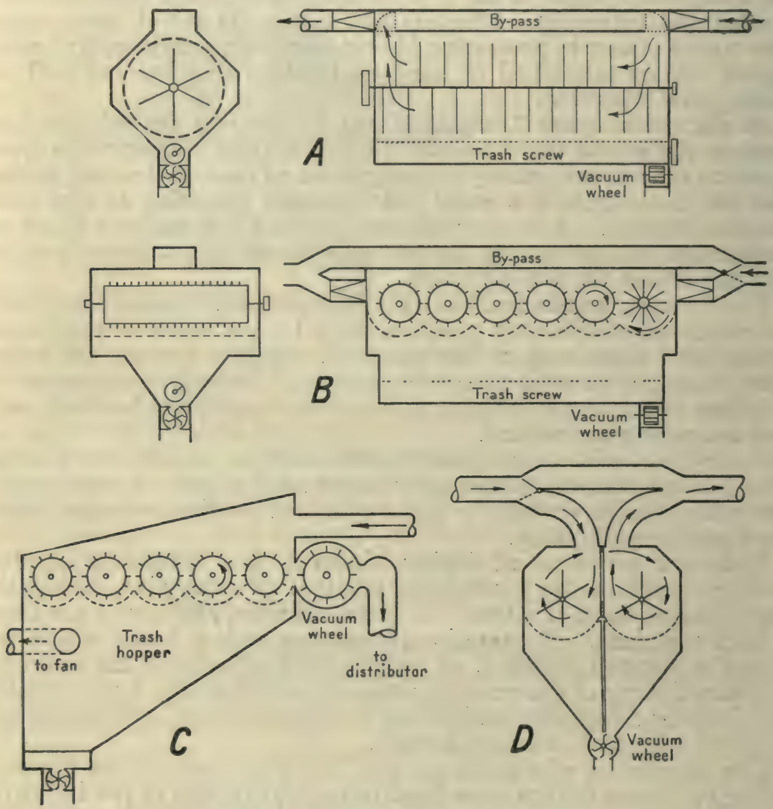


FIGURE 8.—Common forms of air-line cleaners.

Cross-drum types of air-line cleaners (fig. 8, *B* and *C*) are provided with conventional spiked-drum or spider-arm cylinders whose shafts are at right angles to the direction of the air and cotton flow, and with screens scalloped to the curve of the cylinders for separating the foreign matter from the traveling bat of cotton. In the cleaner shown in figure 8, *C*, the seed cotton is conveyed over the top of the cylinders to the rear of the cleaner and thence is propelled forward between the cylinders and the screening surface to a plain separator wheel with rubber tips which acts as the air seal for the cleaner casing. The trash is sucked through the screen and discharged through a sealed wheel at the bottom of the hopper, the fan connection being on one side of the hopper beneath the screen.

A more recent type of air-line cleaner (fig. 8, *D*) combines certain features of previous designs, but introduces a distinctive serpentine division of the seed cotton into right- and left-hand paths of travel which unite at the discharge. Two straight-flow beater shafts are used, each having right-hand and left-hand paddles.

Foreign matter removed by the axial-flow air-line cleaner and by he cross-drum air-line cleaner is shown in figure 9. It is to be noted

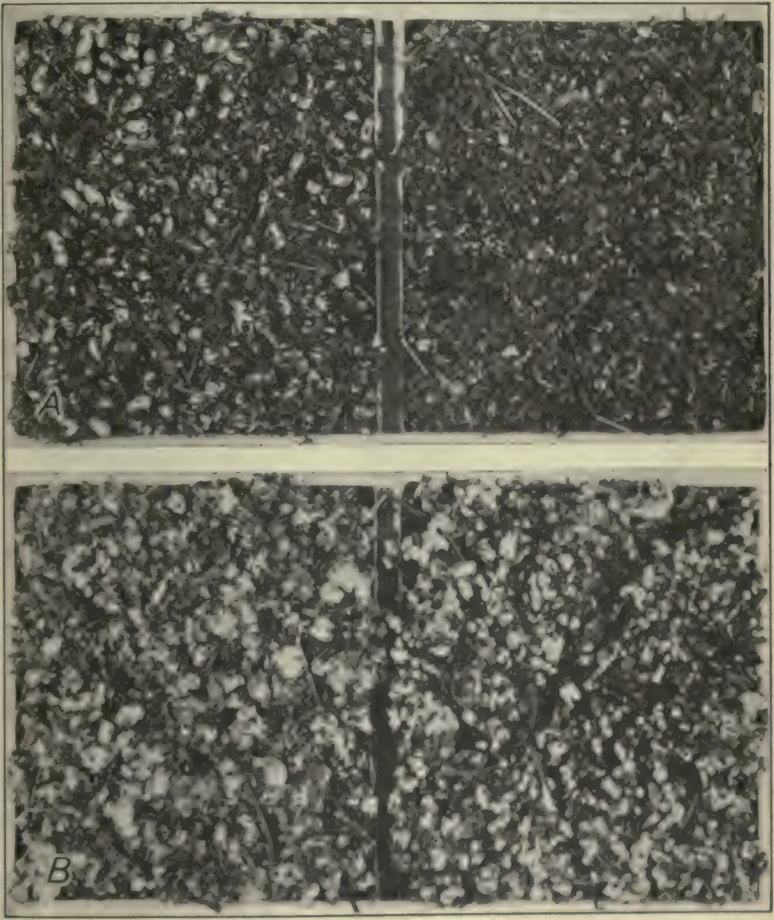


FIGURE 9.—Trash removed by air-line cleaners: *A*, By an axial-flow cleaner; *B*, by a cross-drum cleaner.

that the cross-drum type removed more motes than did the other. As compared with a separator set-up, air-line cleaners generally show some advantage in the grade of the lint, both with trashy and with fairly clean hand-picked cotton, even when a big-drum or a multidrum cleaning feeder is used with a huller gin. Of course they show more benefits to grade when the feeders are of a simpler design that does little or no cleaning, and when the gins are of a plain single-rib type that extracts little or no foreign matter.

OUT-OF-AIR CLEANERS

The increasing number of gins that use the mechanical system of feeding has led to much more extensive use of out-of-air cleaners than of air-line cleaners, although the latter are suitable for use also in mechanical systems. For mechanical systems, the number of cleaning cylinders may vary from 3 to 40 or more; and the construction features of the cylinders may differ widely. The three conventional forms of cleaning cylinders used in out-of-air cleaners are the spiked drum, the paddle wheel, and the spider arm, as shown in figure 10.

In spiked-drum cylinders the drum is commonly 12 inches in diameter and approximately 4 feet long. The spikes, which protrude from 1 to 2 inches, are made of ⅜- or ½-inch-diameter steel rod bent to the desired shape and rounded off to prevent damage to the cotton. The cylinder may be of either wood or metal construction, properly banded to stand up under normal speeds.

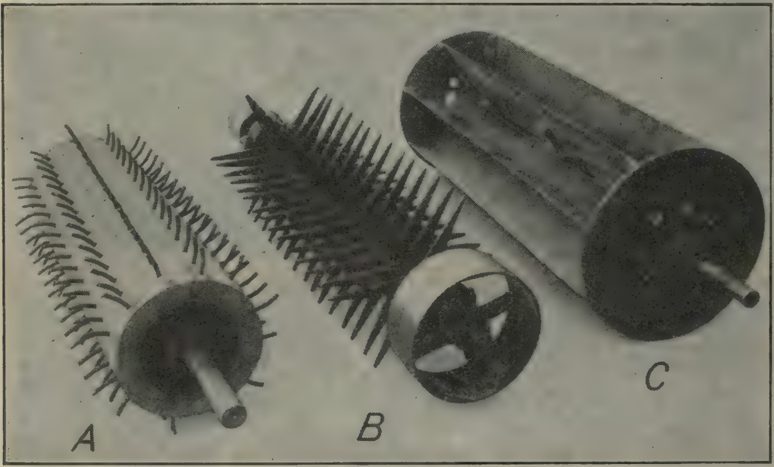


FIGURE 10.—Conventional cleaning cylinders: *A*, Spiked drum; *B*, spider arm; *C*, paddle wheel.

Spider-arm cylinders ordinarily have six rows of heavy, tapering spokes, somewhat similar to a rimless wheel, with the ends of the spokes well rounded. This type of cylinder may be so driven as to give a boll-breaking action, and is often used as an advance or leading cylinder in a series composed otherwise of other-type cylinders to break bolls and thus eliminate crushers which otherwise would be necessary.

Paddle-wheel cylinders may have either 5 or 6 blades, with or without a central core. The 5-blade cylinders usually have short blades upon a pentagonal core, but 6-blade cylinders are being used with disk ends and a plain shaft at the center.

In many areas where rough harvesting does not prevail, except perhaps on the last picking, or what is termed "scrapping", cleaners having 4 to 6 cylinders are used to advantage when adequate cleaning cannot be accomplished by extractors, feeders, and huller fronts. Tests with double-rib huller gins have shown that when big-drum cleaning feeders or unit extractors are used on hand-picked cotton, 4-cylinder cleaners give only slight additional grade benefits.

Spider-arm cleaners expel more motes and stems than spiked-drum cleaners, as is shown by figure 11.

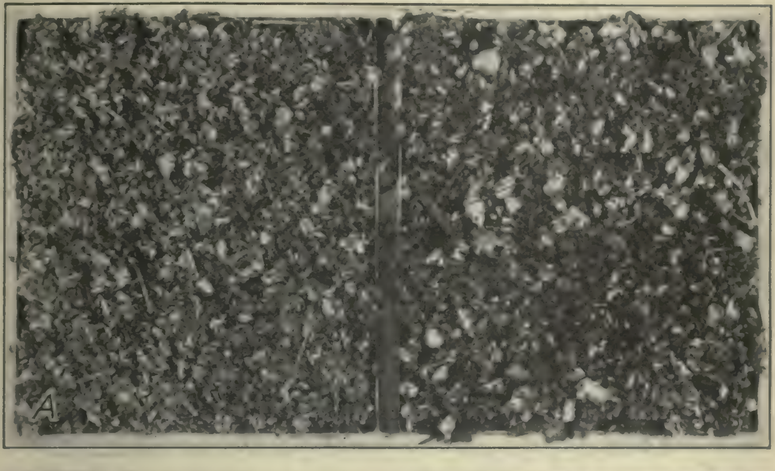


FIGURE 11.—Typical samples of trash removed from four different seed cottons: *A*, By a spider-arm cleaner; *B*, by a spiked-drum cleaner.

Practically all cylinder cleaners, including air-line types, operate at speeds ranging from 300 to 600 revolutions per minute, and an improved practice is to limit the number of cleaning cylinders so that the largest part of the removal of foreign matter can be done by extractors. To this end, on rough cottons it is considered to be good practice to use machinery combinations that include cleaning cylinders, then an extractor, and finally a finishing set of cleaning cylinders.

EXTRACTORS

Extracting differs widely from cleaning because it holds locks of seed cotton on the teeth of circular saws, cylinders, or belts while subjecting the locks to carding and beating action for removing foreign matter. The pitch or forward slope of these teeth is very important in the carding operation, because the teeth must release the locks of cotton without doing any ginning. In many simple ginning plants the fronts of huller gins perform all of the extracting that is done, but in areas where large quantities of coarse foreign matter are to be removed special extracting machines are necessary.

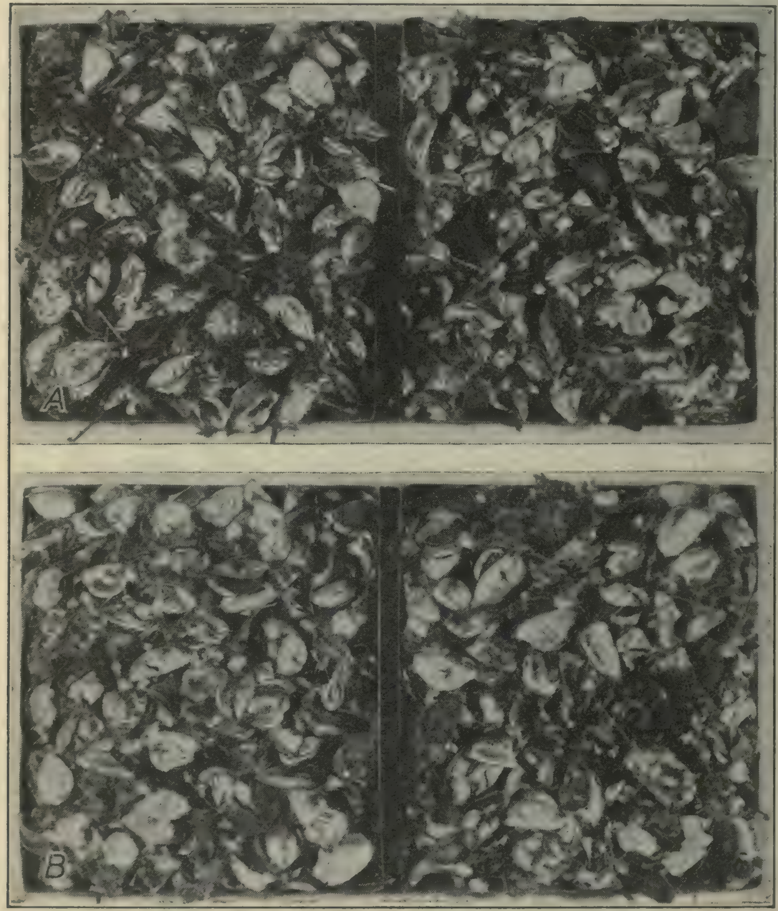


FIGURE 12.—Trash removed by unit extractors; *A*, By multi-saw extractors; *B*, by single-saw extractor.

There are many designs of master and unit extractors on the market. Cleaning screens and cleaning cylinders can be incorporated in these machines, so that the seed cotton can be subjected to a cleaning action before or after extracting, or both. Foreign matter removed by two types of unit extractors is shown in figure 12. More burs and stems were usually removed by the multi-saw unit than by the single-saw unit. For this reason the grade of lint from the former may be expected to be the better.

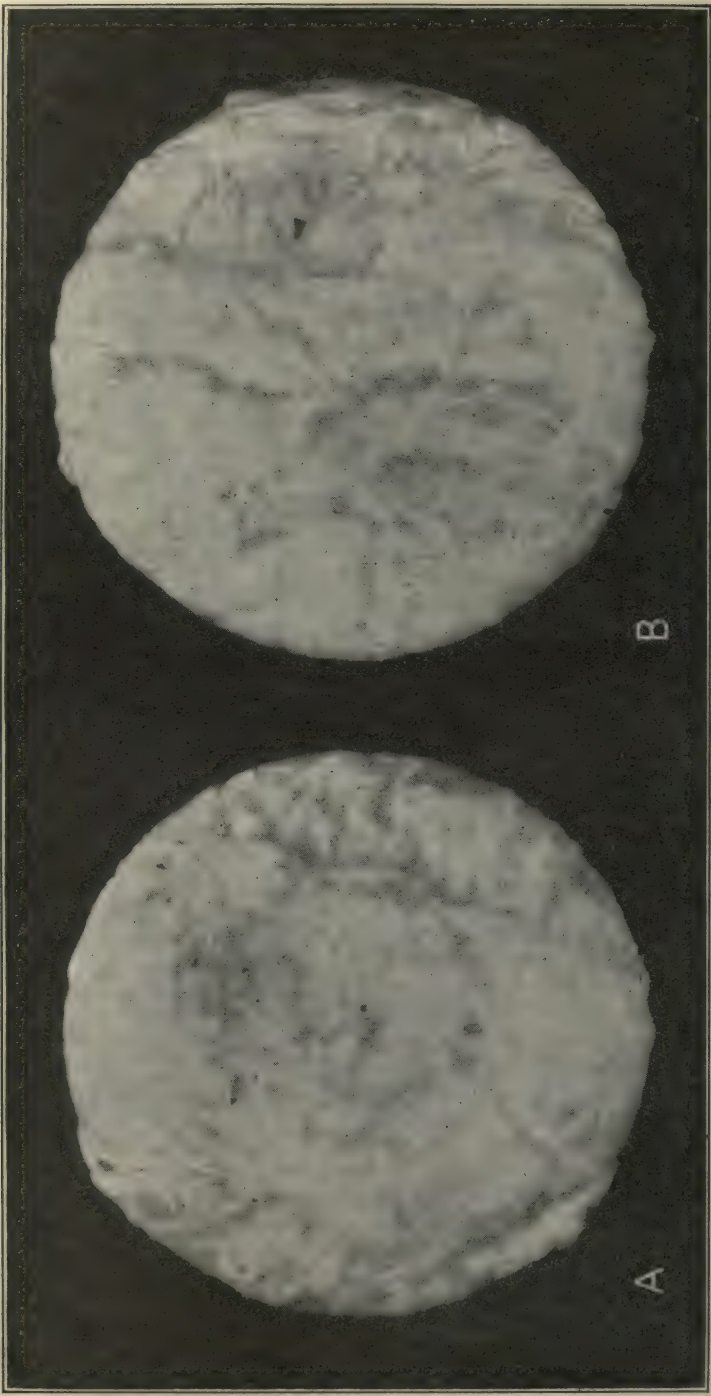
Unit extractors instead of feeders are used more extensively than master extractors, and have proved to be valuable additions to gin plants even in areas where rough harvesting is not practiced. Experiments conducted at the ginning and fiber laboratories of the Department of Agriculture show that on fairly clean picked cotton improved designs of unit extractors give improvements in grade equal to, and sometimes better than, the best air-line cleaners and that on roughly gathered cotton they give considerably greater improvements in grade.

These tests have also shown that, when air-line cleaners and unit extractors are used together, there are sometimes still greater benefits from a grade standpoint because of the greater quantity of trash removed. However, limit of cleaning usually was reached with these machines, and the addition of a 4-cylinder cleaner did not improve the grade.

The benefits in grade obtained by using these units separately and in combination are illustrated in figures 13 and 14 for short-staple and long-staple cottons, respectively. The samples shown were ginned on a double-rib huller air-blast gin, with a loose seed roll and a normal or manufacturer's rated gin-saw speed. Evidently the addition of the extractor units was very helpful to grade in the case of both cottons. The staple length of these cottons was not generally affected by using cleaners and extractors. But if damp or wet long-staple cottons had been subjected to all of the units indicated, or to a greater number of units than were required for adequate cleaning, it is possible that the quality of the resulting ginned lint would have been injured. Excessive handling causes roping of the locks of such cotton, and when the saws strike these ropes damage is likely to be done.

In the light of these facts it is desirable that both cotton farmers and ginners should be well acquainted with cleaning and extracting processes, so that a good machinery combination may be chosen for handling the seed cotton satisfactorily in each locality. The operating costs and ginning charges should be in keeping with the class of service required in the community. In some parts of the Cotton Belt extensive cleaning and extracting equipment is a vital necessity; in other parts less elaborate equipment may be enough.

Some effects of different combinations of cleaning and/or extracting equipment on grade of lint from Mississippi Delta long-staple and west Texas short-staple seed cottons harvested by different methods are shown in figures 15 and 16. As may be seen, the elaborate processes of cleaning and extracting failed to bring about in the roughly harvested cotton lint of as high a grade as the simplest processes produced in the hand-picked cotton. In most cases the difference was about a full grade. But some improvements in grade were caused by the use of these machinery combinations. In the roughly harvested cotton from Texas there was a favorable effect on grade with each addition of cleaning and extracting units. In the Mississippi hand-picked and hand-snapped cottons also there was a tendency for the grade to improve as additional cleaning and extracting units were used.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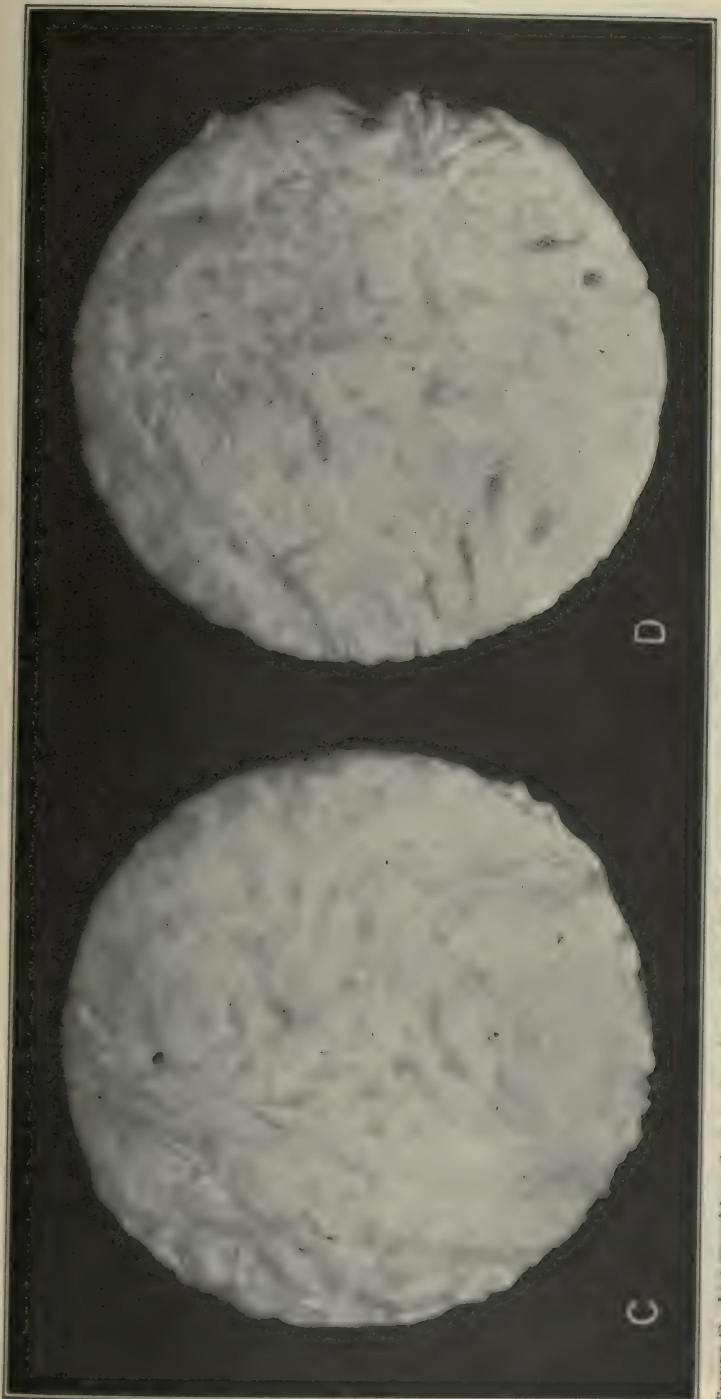
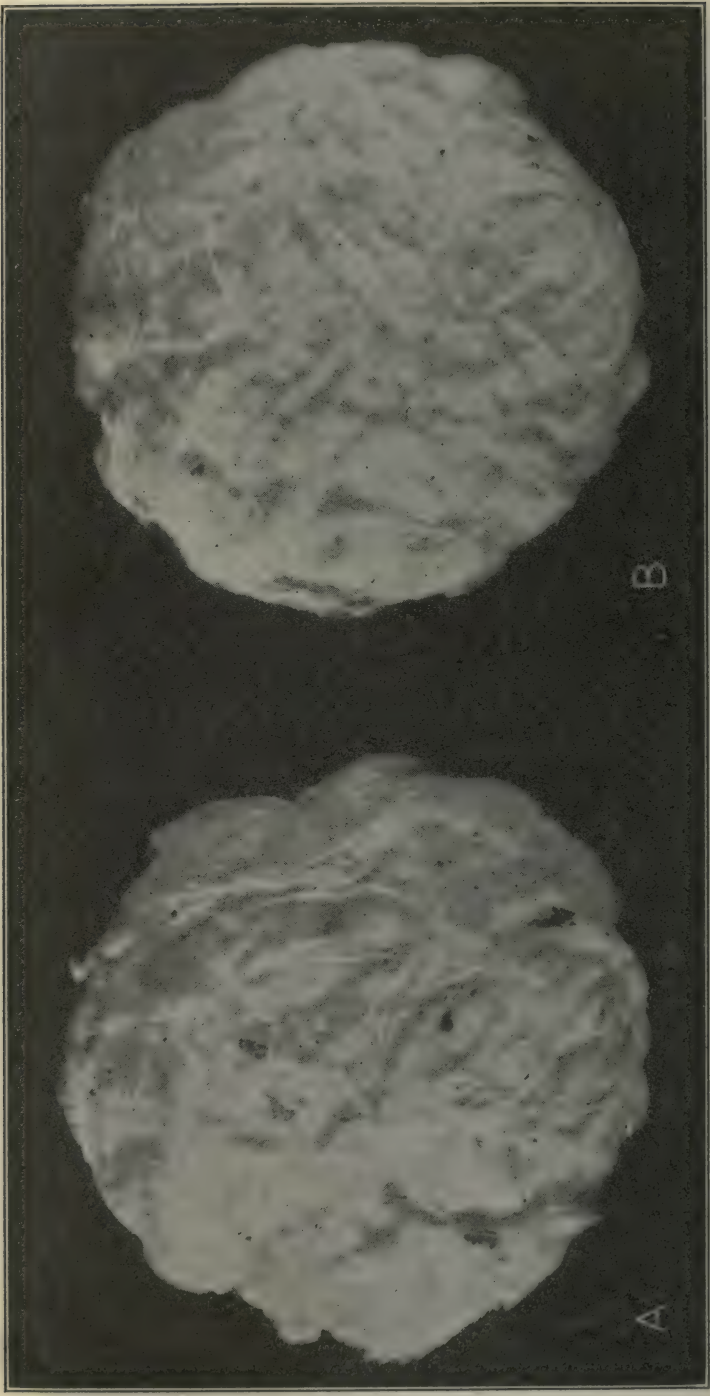


FIGURE 13.—Lint ginned from short-staple seed cotton cleaned by different processes: *A*, By revolving-screen separator only; *B*, by 6-cylinder air-line cleaner and revolving-screen separator; *C*, by revolving-screen separator and unit cleaner-extractor-feeder; *D*, by 6-cylinder air-line cleaner, revolving-screen separator, and unit cleaner-extractor-feeder.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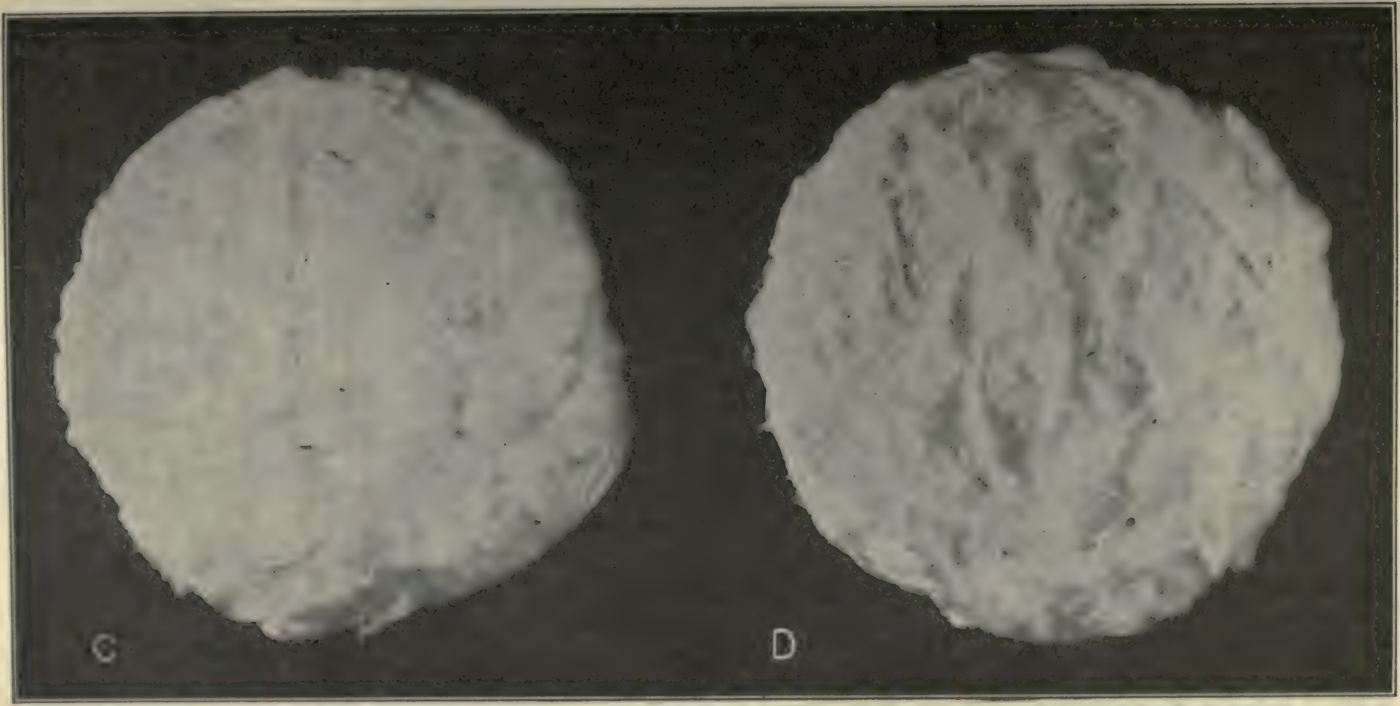

FIGURE 14.—Lint ginned from long-staple seed cotton cleaned by different processes: *A*, By cleaner-separator only; *B*, by 6-cylinder air-line cleaner and cleaner-separator; *C*, by cleaner-separator and unit cleaner-extractor-feeder; *D*, by 6-cylinder air-line cleaner, cleaner-separator, and unit cleaner-extractor-feeder.

These and other tests conducted by the Department of Agriculture emphasize how desirable it is that the farmer use care in harvesting his cotton crop, even though present-day gin machinery is fairly effective in cleaning dirty, trashy, or roughly harvested cotton. Complaints of cotton spinners suggest that excessive use of cleaning and extracting machinery may seriously damage other elements of lint quality than grade.

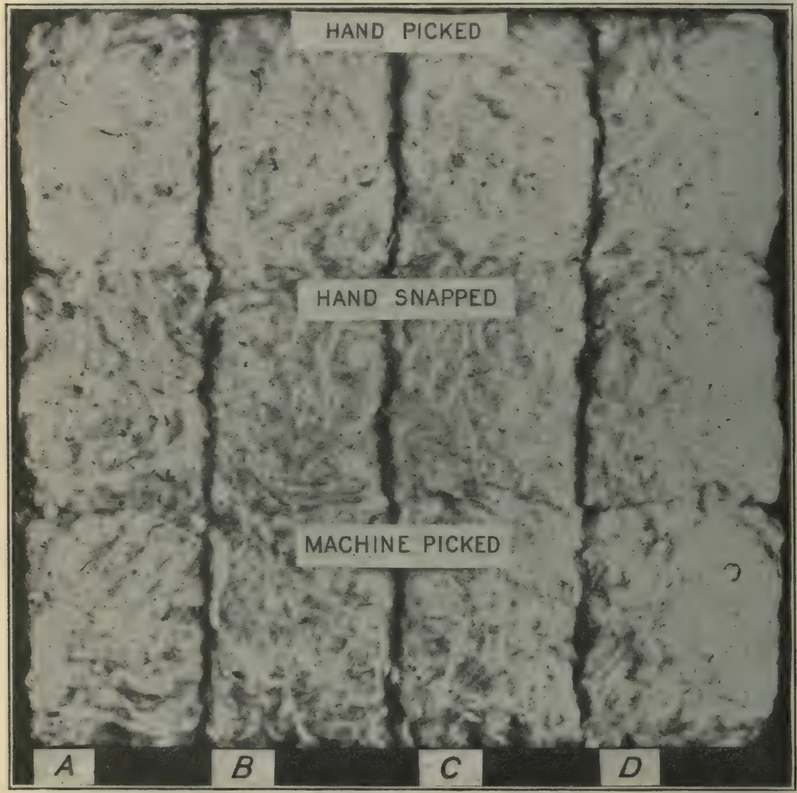

FIGURE 15.—Lint ginned from Mississippi long-staple seed cotton variously harvested, cleaned by different processes: *A*, By revolving-screen separator only; *B*, by revolving-screen separator and 4-cylinder spider-arm cleaner; *C*, by 6-cylinder air-line cleaner, revolving-screen separator, and 4-cylinder spider-arm cleaner; *D*, by 6-cylinder air-line cleaner, revolving-screen separator, 4-cylinder spider-arm cleaner, and unit cleaner-extractor-feeder.

FEEDERS

Feeders were first used to control the feeding of seed cotton into the gin stands. At first the front feeder was used (fig. 17). With this type of feeder the wagons of seed cotton could be driven into the gin plant and unloaded directly into the feeder boxes by means of baskets or forks. Later a flat feeder was developed (fig. 18), which is still used in some sections. This form brought with it various methods of regulating the rate of feeding, and cleaning cylinders and screens were finally provided in it. These cleaning cylinders were about 12 inches in diameter, were constructed of wood, and had rows of round-ended spikes about 1 inch long. This type was the first attempt to extend the function of feeders to doing some cleaning of the seed cotton, but much fine dirt and dust was shaken out through the slats of the flat feeder belts.

What is now known as the small-drum cleaning feeder was developed from the improved flat feeder, because the vertical form was found to be more adaptable than the horizontal for connecting with pneumatic chutes and belt distributors. However, the size and construction of the cleaning cylinder was retained in the small-drum feeder. Figures 19 and 20 show small-drum feeders installed on cotton gins equipped with different systems of feeding.

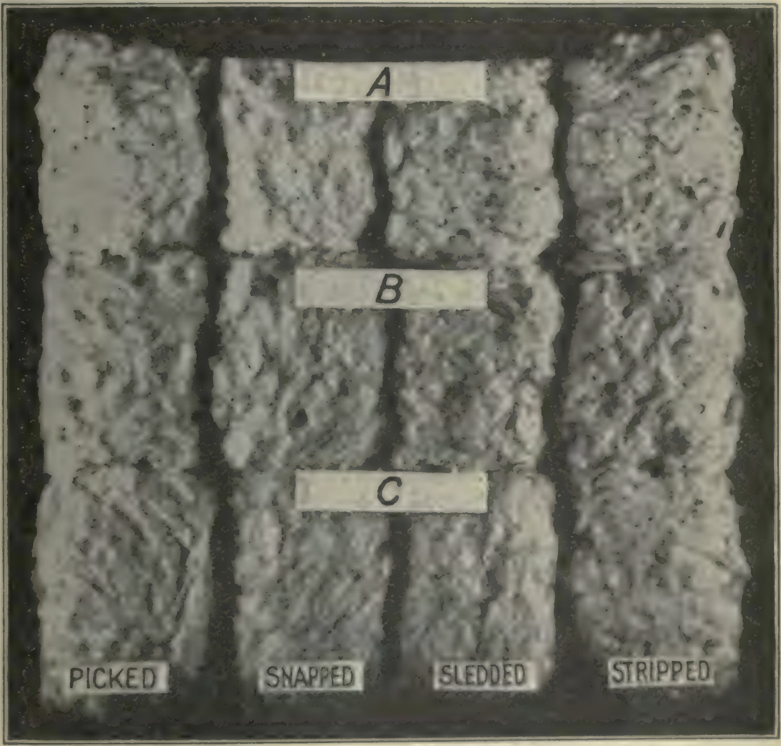

FIGURE 16.—Lint ginned from Texas short-staple seed cotton, variously harvested, cleaned by different methods: *A*, By revolving-screen separator and 4-cylinder spider-arm cleaner; *B*, by 6-cylinder air-line cleaner, revolving-screen separator, and 4-cylinder spider-arm cleaner; *C*, by 6-cylinder air-line cleaner, revolving-screen separator, 4-cylinder spider-arm cleaner, and unit extractor.

Later enlargement of drums and cleaning surfaces was a natural outgrowth of better manufacturing and standardization methods, and provision for more cleaning at this stage in the ginning process resulted in present-day units known as big-drum cleaning feeders. Instead of these big-drum feeders some gins use certain kinds of multidrum feeders having equivalent cleaning capacity. The screening surfaces and cleaning effects of both big-drum and multidrum cleaning feeders are superior to those of the small-drum feeders.

Tests at the Department's cotton ginning and fiber laboratories show that, with hand-picked cotton, when big-drum cleaning feeders or overhead master cleaners are not overloaded the cleaning effects are nearly identical.

Cotton gins in some sections encounter a great deal of very roughly harvested cotton. The ginner may make use of either master or unit extractors in handling such cottons. Using unit extractor-feeders rather than big-drum cleaning feeders is permissible because they accomplish cleaning as well as extracting; so in selecting the feeders for his gin stands, the ginner has a number of well-balanced machinery combinations from which to choose.

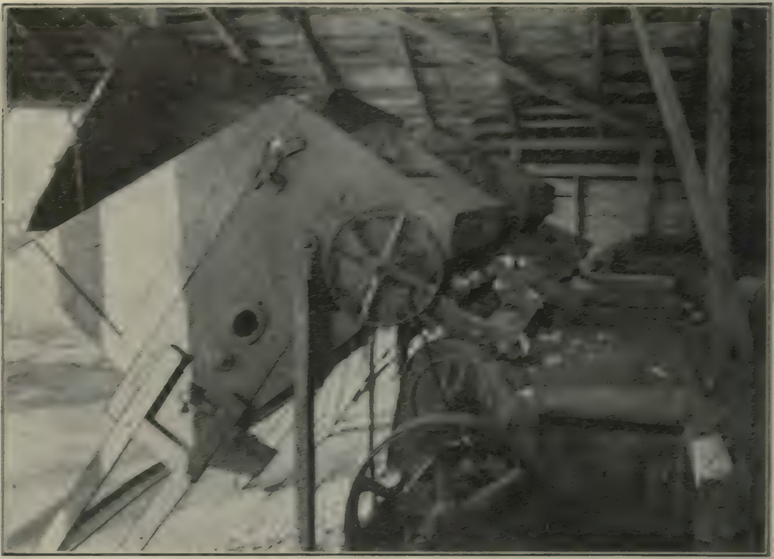

FIGURE 17.—Front feeders on gin stands.

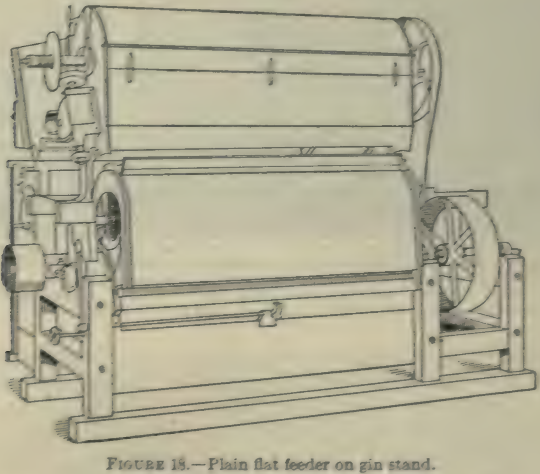

FIGURE 18.—Plain flat feeder on gin stand.

Feeders, like cleaners and extractors, require inspection and good maintenance of their screens and cylinders.

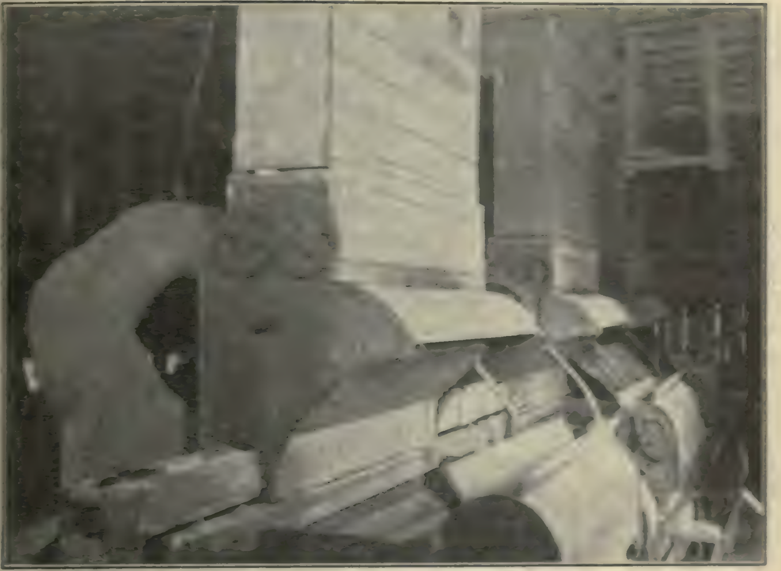

FIGURE 19.—Small-drum cleaning feeders, with pneumatic distribution system.

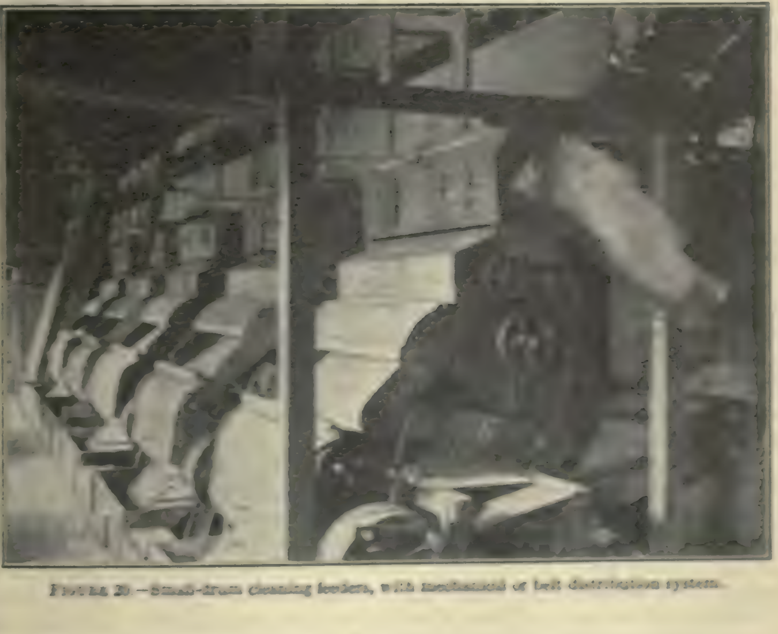

FIGURE 20.—Small-drum cleaning feeders, with mechanical or belt distribution system.

GIN STANDS

TYPES OF GINS

Two principal types of saw gins are in use today—air blast and brush. Each type includes plain designs in which the seed cotton is fed directly into the roll box, and huller designs in which it is fed to picker rollers designed to extract burs and trash. In the huller gins, the gin saws draw the seed cotton from the picker roller of the huller breast through the huller ribs into the roll box. Figure 21 shows cross sections of four plain and huller gin fronts.

The double-rib huller fronts predominate. The protection they give to the gin saws and their elimination of foreign matter like burs, hulls, and leaf stems have made them very popular. In only the Southeastern States are the single-rib plain gins now found to any extent. It is important to keep foreign matter from the seed roll so that the ginned lint will not be contaminated as is likely to happen when the gin saws have to cut through a trash-laden seed roll in the ginning breast or roll box.

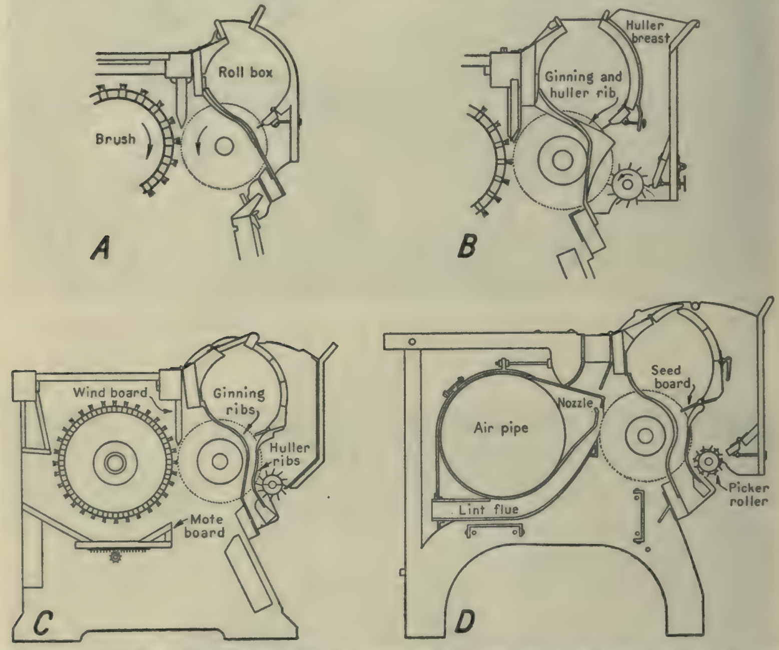

FIGURE 21.—Kinds of gin fronts: *A*, Plain brush gin; *B*, single-rib huller brush gin; *C*, double-rub huller brush gin; *D*, double-rib huller air-blast gin.

If rough trashy cotton like that harvested late in the season must be ginned, a huller gin will give the best results when the picker roller is set as far away from the huller ribs as possible. This adjustment allows a free discharge of foreign matter. If the trash does not discharge readily from the huller front, the gin saws drag in parts of it, the ginning capacity is reduced, chokages follow, and a poor grade of lint is turned out. Then the part of the trash drawn into the roll box that does not go with the lint is discharged with the seed and lowers its value.

With a plain gin it is usually advisable to install a master extractor or a unit extractor-feeder if trashy cotton is to be ginned.

The gins shown in figure 21 are all of the type which "mote by gravity"; that is, they cast off motes and some foreign matter into the spaces below the saws. Other efficient and economical designs of gins mote by centrifugal force, discharging the motes overhead between the back of the ribs and the brush or the air-blast nozzle.

RATE OF FEEDING

The rate at which seed cotton is fed to the gin saws has an important influence on the quality of the lint produced. The cotton farmer pays dearly when he insists on crowding his cotton through the gin. Both the air-blast and brush gins give a smoother and more valuable sample when the gin stands are fed so as to obtain a loose seed roll. The rate at which the seed cotton should be fed to the gin saws depends on the amount of moisture in the seed cotton, the length of the staple, the size and fuzziness of the seed, and other physical characteristics of the cotton. Long-staple cotton should be fed and ginned more slowly than short-staple cotton, and green or damp cotton more slowly than dry cotton. A loose seed roll produces a smoother sample than a tight seed roll. A ginner who is feeding the gin stands at the lowest rate and still getting a rough sample can often improve it by slowing down his feeder drive. Setting the seed board wide open also helps because it permits a good discharge of seed and thus contributes to a loose seed roll.

SEED-ROLL DENSITY

Samples ginned with a loose seed roll average from one-third to almost a full grade better than those ginned in the same way except with a tight roll, depending on the staple length and the moisture of the cotton. On some individual cottons the resulting lint is sometimes two full grades better. Using a tight seed roll not only lowers ginning preparation, 1 of the 3 factors of grade, but also affects the observed color and leaf, the other 2 factors of grade. Fast ginning therefore should be avoided.

With the same group of cottons of 1⅛ inches and greater length discussed on page 9, the benefits of using a loose seed roll instead of a tight seed roll averaged approximately $4 per bale for those of 12-percent and greater moisture content, and averaged slightly more than $1 per bale for those of less than 12-percent moisture content. With the cottons of less than 1⅛ inches length, the average advantage of the loose seed roll was about $1 per bale for each moisture group.

The advantages of loose-roll ginning combined with seed-cotton drying are worth considering. With the longer cottons having a moisture content of 12 percent or more, drying the seed cotton and ginning with a loose seed roll yielded a much better lint than was obtained by ginning the same cotton without drying and with a tight seed roll. With the former method the lint averaged more than $7 per bale, or nearly 20 percent, more than the other lint. With the shorter cottons, similar difference in treatment yielded an average difference of almost $1.50 per bale, or about 4 percent, in the market value of the lint.

Illustrations of the superiority of loose-seed-roll samples over tight-seed-roll samples are shown in figures 22 to 27, for short-staple and long-staple cottons. Note the very nappy and rough preparation of

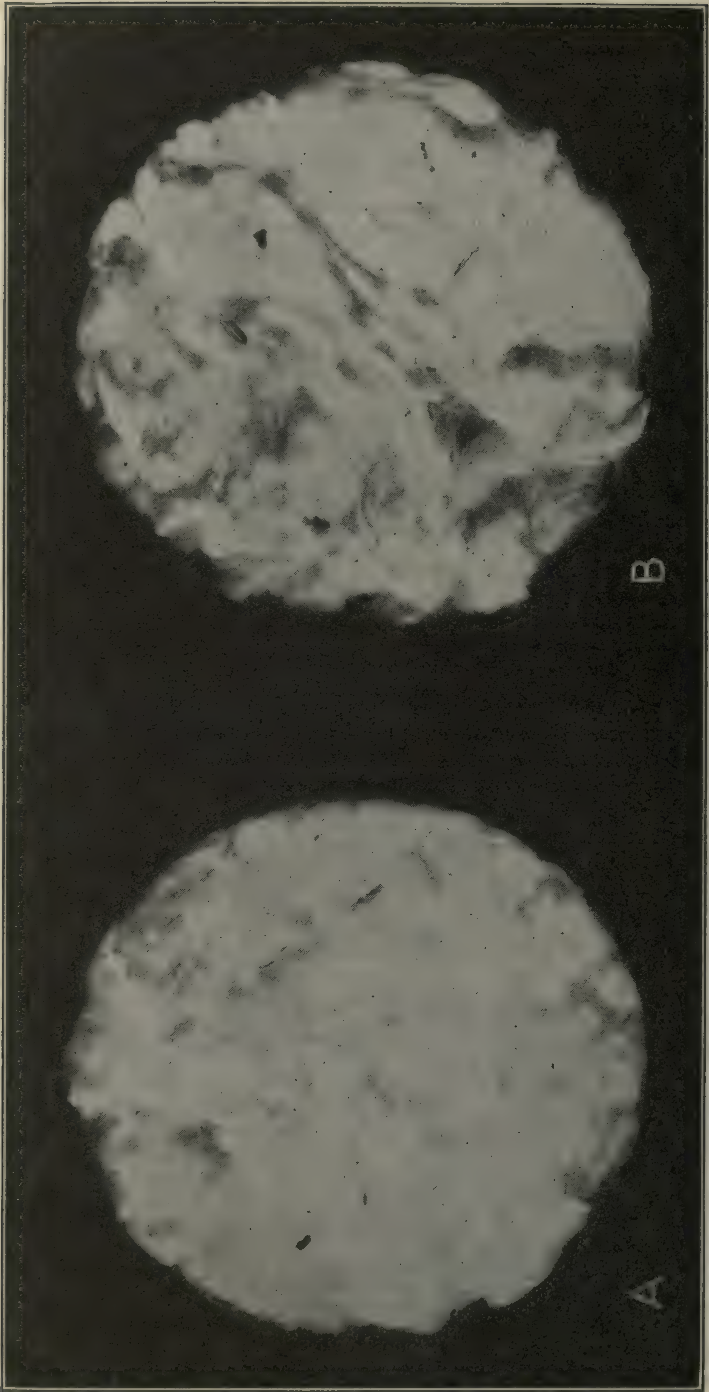

FIGURE 22.—Lint samples of short-staple cotton ginned at a saw speed of 400 revolutions per minute: *A*, With loose seed roll; *B*, with tight seed roll.

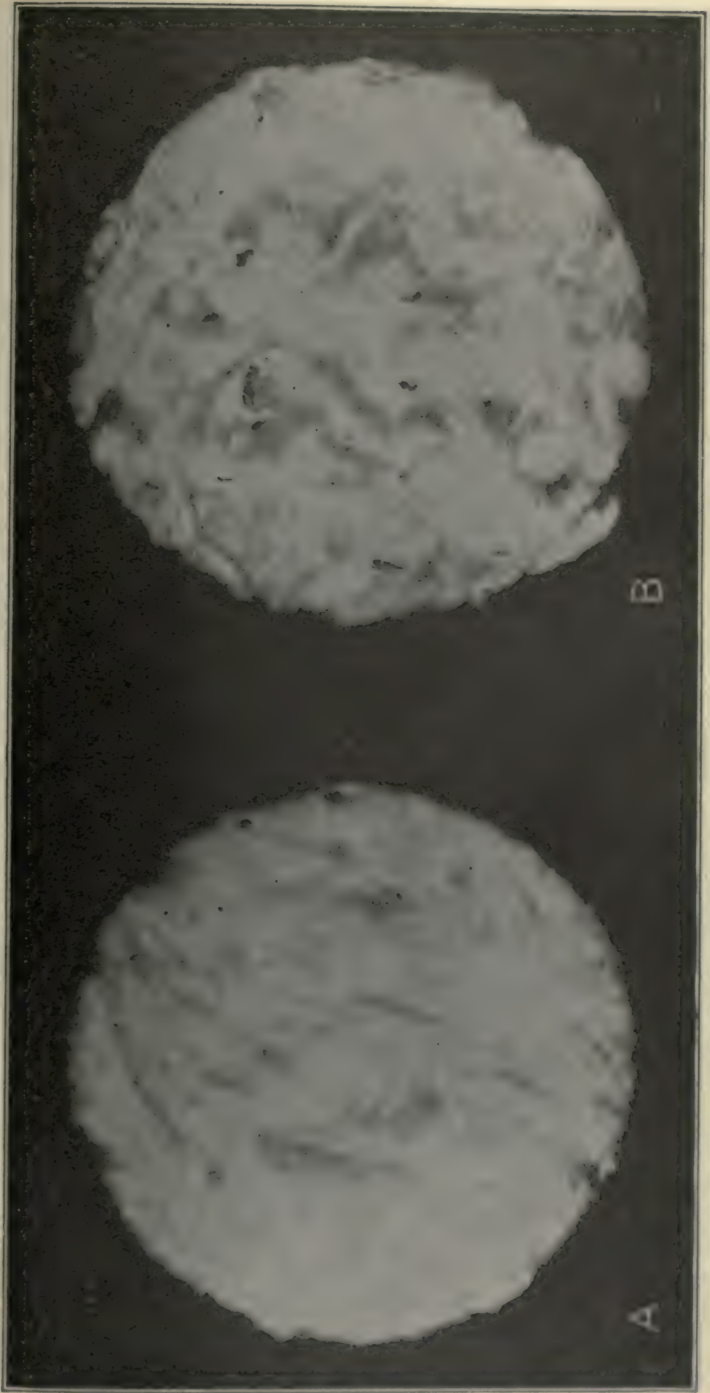

FIGURE 23.—Lint samples of short-staple cotton ginned at a saw speed of 500 revolutions per minute: *A*, With loose seed roll; *B*, with tight seed roll

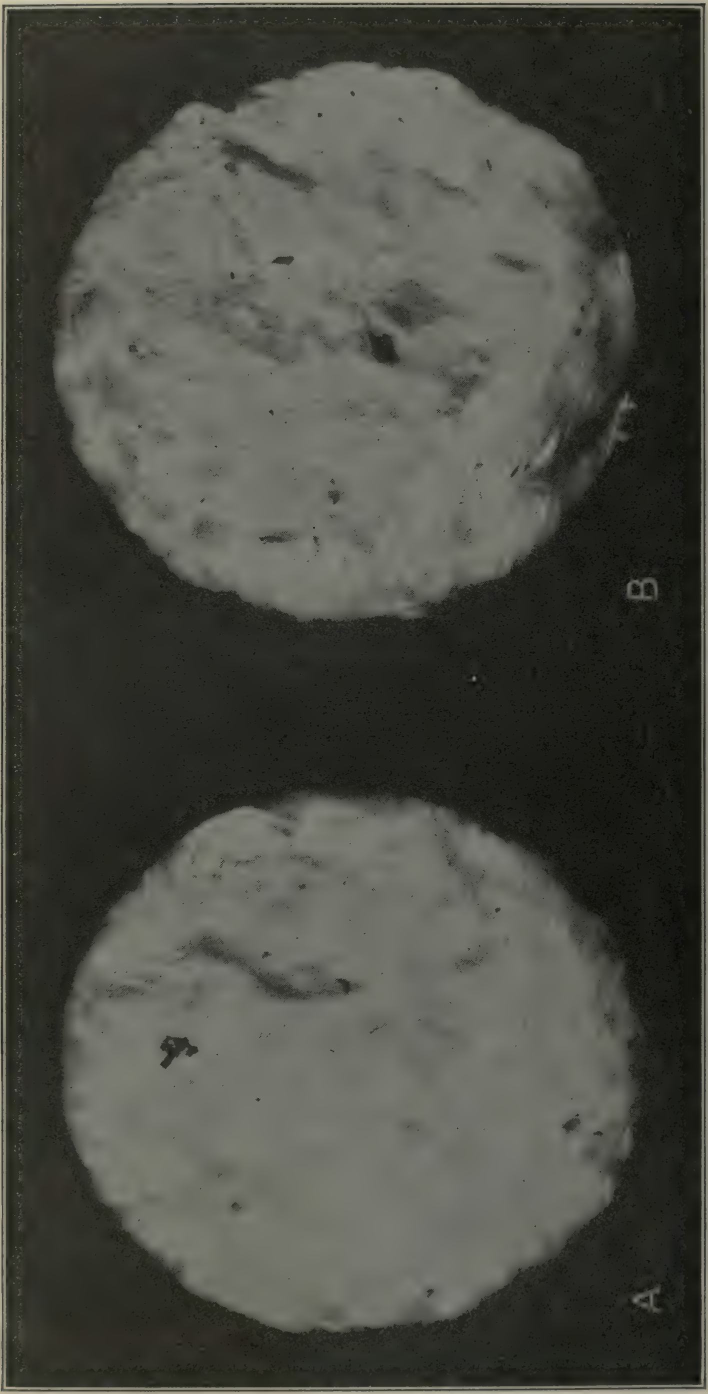

FIGURE 24.—Lint samples of short-staple cotton ginned at a saw speed of 600 revolutions per minute: *A*, With loose seed roll; *B*, with tight seed roll.

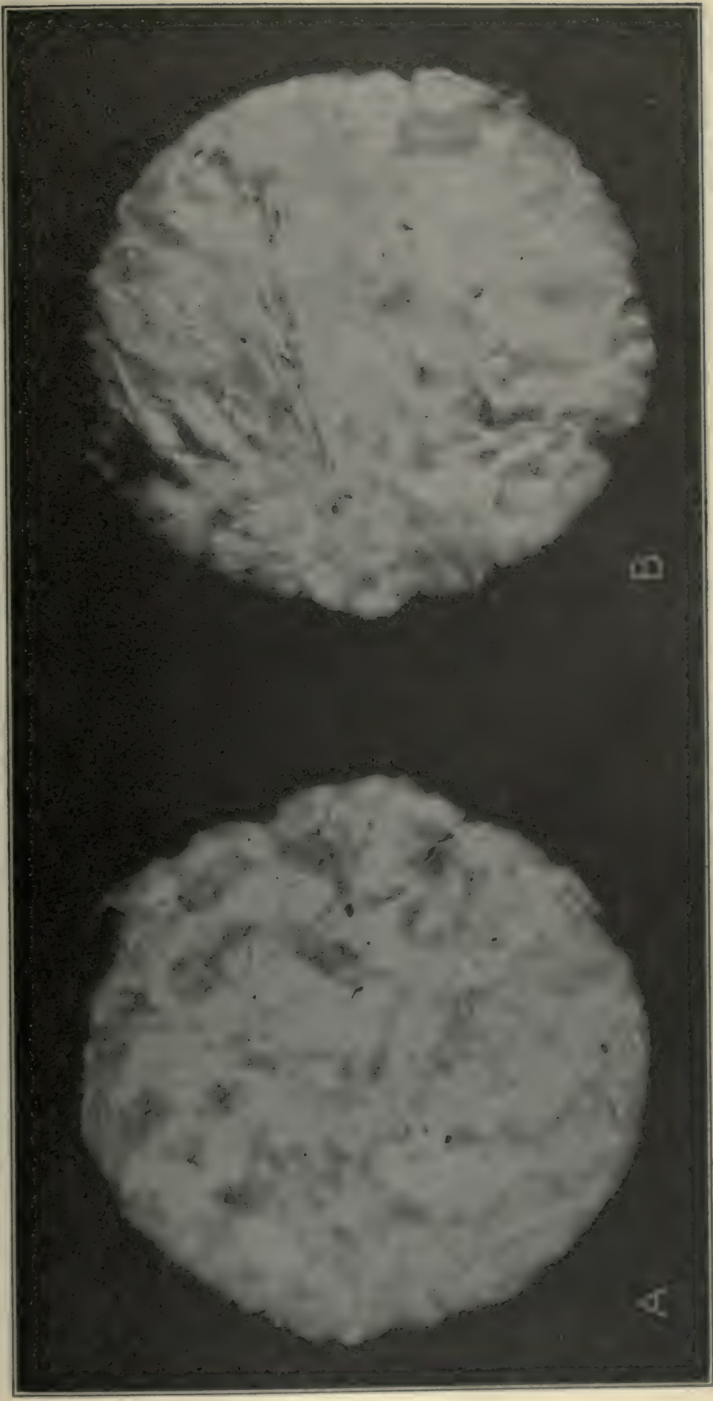

FIGURE 23.—Lint samples of long-staple cotton ginned at a saw speed of 400 revolutions per minute: *A*, With loose seed roll; *B*, with tight seed roll.

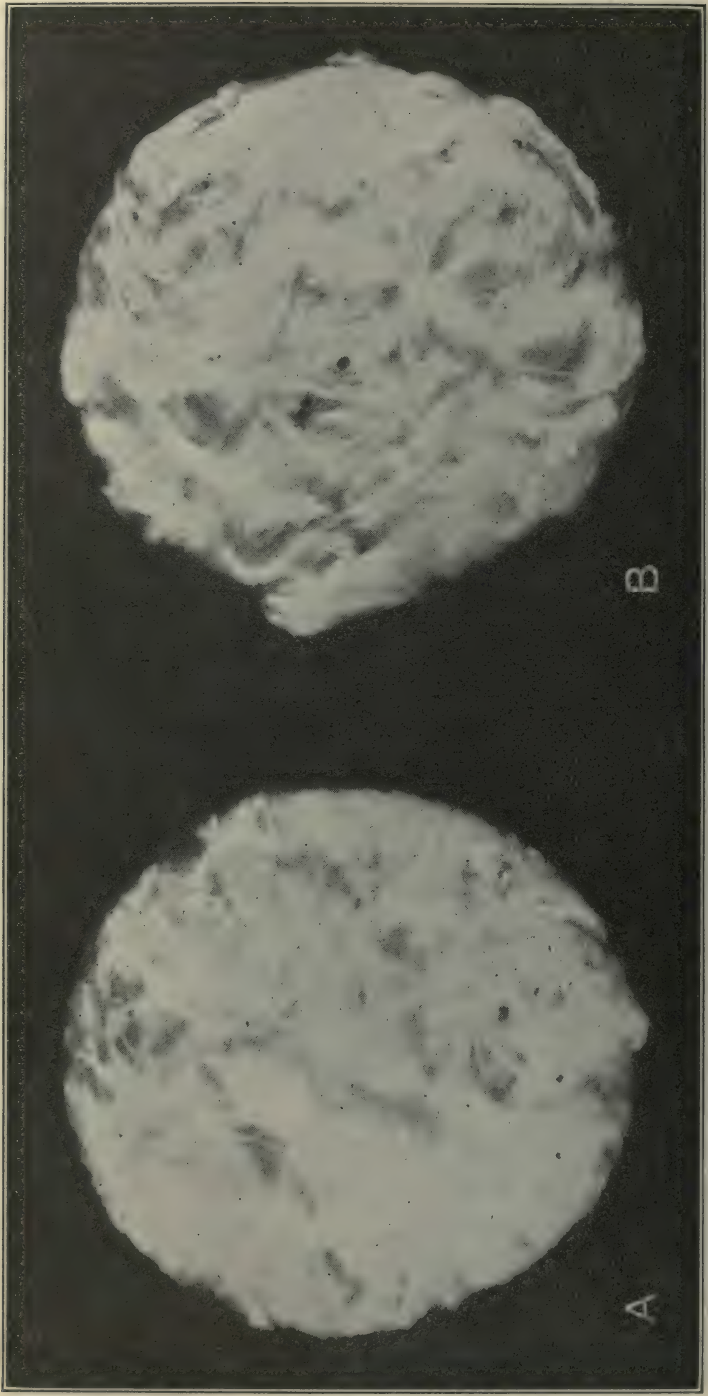

FIGURE 26.—Lint samples of long-staple cotton ginned at a saw speed of 500 revolutions per minute: *A*, With loose seed roll; *B*, with tight seed roll.

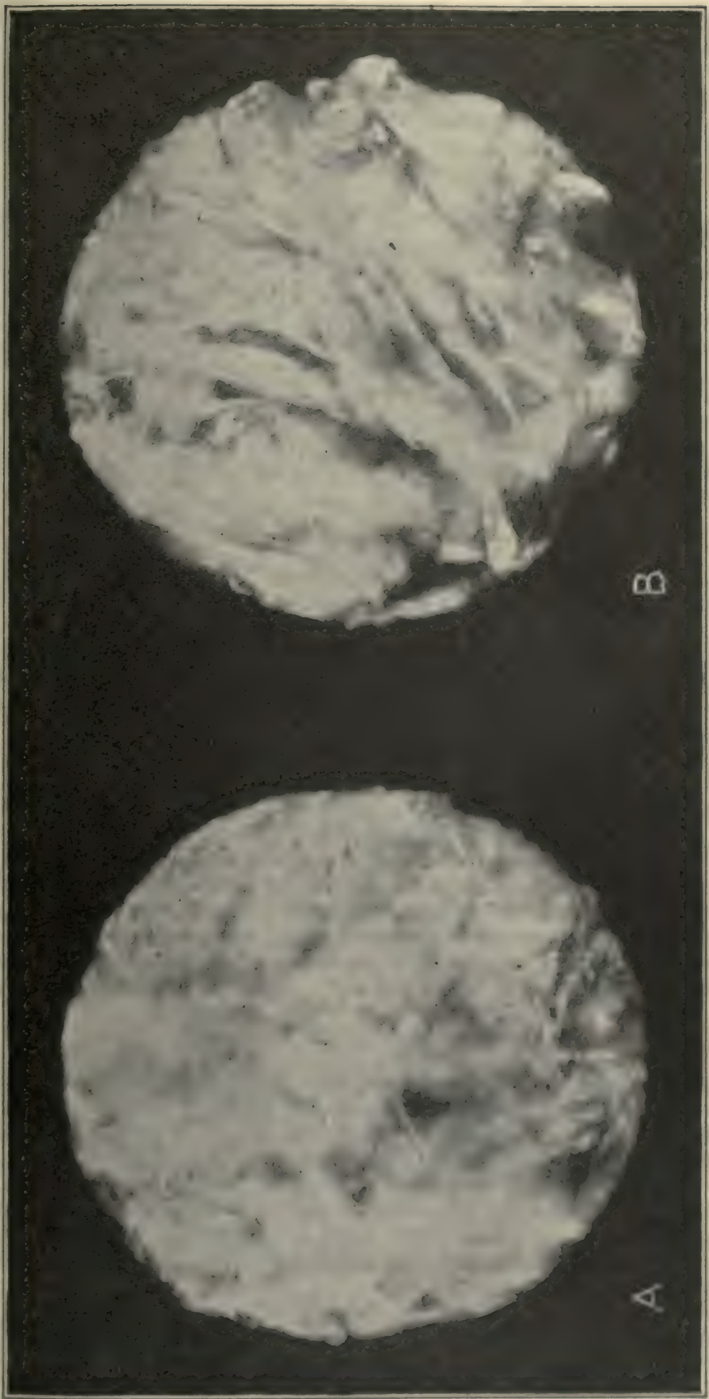

FIGURE 27.—Lint samples of long-staple cotton ginned at a saw speed of 600 revolutions per minute: *A*, With loose seed roll; *B*, with tight seed roll.

the tight-seed-roll samples on the right as compared with the loose-seed-roll samples on the left.

Using a loose seed roll has several advantages from a mechanical point of view. The loose seed roll requires less power, causes less wear and tear on gin saws and ribs, and causes less chokages in huller fronts, ribs, etc.

GIN-SAW SPEED

Gin-saw speed is secondary to roll density in its effects on the quality of lint (figs. 22 to 27). Present-day gins are designed to permit a certain amount of flexibility in saw speeds without causing much change in lint quality or mechanical operation. It appears to be generally advisable to follow the manufacturer's recommended speeds, although departures up to 100 revolutions per minute from these speeds have not thus far shown any appreciable effect on the quality or quantity of the lint. Within this range the small effects produced by changes from the manufacturers' speeds indicate a tendency for grade of lint to decline and outturn of lint to increase with advance in saw speed. Excessive speeds should be avoided for the sake of both the cotton and the machinery.

MOTE-BOARD ADJUSTMENT

The mote board should be so adjusted that the undesirable substances commonly known as motes can be readily expelled from the lint without loss of good fibers. It is good practice to observe the moting action of the gin and keep the mote board set to suit the cotton as the season progresses, checking adjustments by examining the press sample for motes and by observing the material cast off at the moting position.

The construction and the means for adjusting mote boards are varied, depending on the type and make of the gin stand. Brush gins are usually provided with movable mote boards placed below the brush in a horizontal or inclined position to form an extension to the bottom of the lint-flue connection. Air-blast gins usually have the equivalent of mote boards in the lower lip of the lint flue, which is located a few inches below the air-blast nozzle. Gins that mote by centrifugal force do not have mote boards, but may have adjustable devices of various kinds so that the moting can be somewhat regulated mechanically.

FANS AND COTTON PIPING

The fans used in cotton ginning are usually of the fully housed type, comprising a bladed wheel which revolves in a scroll or housing. These fans are designated by number (no. 30, no. 35, etc.). In a general way these numbers indicate the number of hundreds of cubic feet of air that the fan will handle per minute. Thus a no. 30 fan will normally deliver about 3,000 cubic feet of air per minute at its rated speed, and a no. 45 will deliver 4,500 cubic feet of air per minute. Increasing the speed for any size increases its volume or its pressure or both.

Fan wheels that have no side plates or shrouds are called plain wheels (fig. 28, *A*). Fan wheels designed for greater efficiency or for special purposes are frequently provided with shrouds (fig. 28, *B*). Cotton should not be allowed to pass through fans with plain or shrouded wheels. The fans are protected against such a possibility by the screens in the separators or pneumatic elevators. Some installations eliminate the separators or pneumatic elevators by making use of a Rembert wheel (fig. 28, *C*), in which the perforated steel disk fastened to the side of the wheel prevents the cotton from passing through the blades of the fan. This wheel is necessarily a few inches narrower than the other types, to give room for the cotton to pass.

Rembert-type fans are used to deliver seed cotton to storage bins and to feed seed cotton through cotton driers. The standard types of fans with plain or shrouded wheels are generally used in the ginning establishment for handling the cotton through the piping from the wagon telescope to the separator and for blowing ginned seed to storage spaces or railway cars. Standard fans also provide adequate volumes of air for air-blast gins.

In all fans used at cotton gins it is customary to employ sheet-metal cotton piping ranging from 9 to 16 inches in diameter, and to maintain an air velocity within such pipes of 2,500 to 4,500 linear feet per minute in order to handle seed cotton and ginned seed. As a result of such velocities the air pressures are high, and there is chance of inefficient and costly operation. Fans are frequently run at too high a speed, which tends to excessive power cost, or they are run at too great pressure. Many systems allow the fan to be heavily loaded at times when the cotton gins are idling. This is a costly and faulty practice, which is encountered even in some gins well operated in other respects.

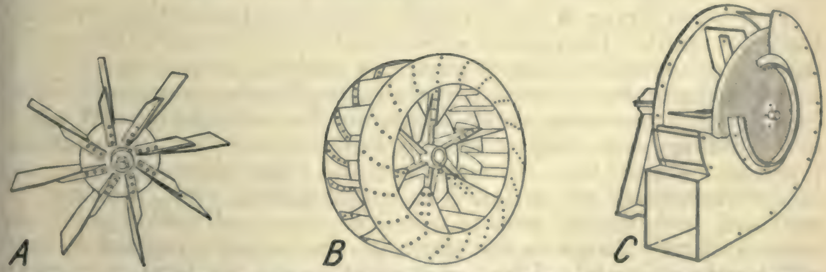

FIGURE 28.—Representative types of gin-fan wheels: *A*, Plain 8-blade wheel; *B*, shrouded 18-blade wheel; *C*, Rembert-type wheel, in fan casing.

High-efficiency fans of slow speed have greater diameters and narrower wheels than those ordinarily used by cotton ginners. Other improvements recommended are shrouded wheels having from 12 to 18 blades, universal housings that may be used either right hand or left hand and permit adjusting to 8 or more discharging positions, ball bearings, lower speed ratings, and especially lower power requirements. These add to the first cost of a fan, but they are well worth while because they reduce the power consumption and pay for the fan over a reasonable period of operation.

When a new ginning plant is to be built, it is advisable to specify the type and size of fans best suited to the particular work to be done, and when replacing a fan that is worn out or is using too much power an efficient type should be selected. The representatives of electric-light and power companies in most cotton-growing States have instruments for measuring fan speeds, volumes, and pressures.

After having learned these facts about the old unit, the right new one can be intelligently selected from the performance tables that most fan manufacturers will supply on request. These tables usually offer a rather wide range of selection in designs and performances.

In selecting Rembert-type fans, it is desirable to obtain oversize units in order to avoid excessive speeds. Thus a size 45 casing with a size 40 wheel and Rembert disk is more desirable than a size 40 casing with only a size 35 wheel and disk. The larger fan will ordinarily deliver air volumes approximately equal to the volumes of a size 35 standard fan; the smaller unit is about equal in delivery to a size 30 standard fan. Some manufacturers mark such fans 45–35 or 40–30 to designate this capacity limitation. Rembert-type fans can frequently be used for more than one purpose. For instance, one can be used during ginning as an unloader fan in connection with pneumatic elevators or a mechanical separator, and during other periods as a cotton-house loader,by using a valved by-pass pipe around the pneumatic elevator or separator. In cotton drying the Rembert fan is useful because it can be used without a separator and thus uses less power, or it can be combined with cotton-house loading so that it will not only serve for the drier but will also be available for delivering cotton to bins or transferring it from one bin to another.

The cotton piping in gins is usually constructed according to certain trade standards. Galvanized sheet metal of no. 22 gage is commonly used; joints are of the slip or stovepipe variety, secured tightly with bands that are drawn up with stove bolts; elbows are made in either 5- or 7-segment sections, depending on the diameter of pipe and radius of curvature; and adapter fittings are built up to make suitable junctions between fans, cotton piping, and other pieces of apparatus. Wagon telescopes are included in cotton-piping work, and can be provided with flexible canvas joints or patented socket joints of various forms. As a rule the telescopes are counterweighted so they will be approximately 7 feet above the wagon platform or runway when not in use.

PRESSING AND BALING

The ginned lint is blown from the gin saws to the lint flue by the air current created by the brushes of brush gins, or by the air from the blast fan of air-blast gins. The lint flue should be properly proportioned and should contain no obstructions such as rivet heads or rust to accumulate lint and dust, for such material when finally discharged detracts from the quality of the bale of cotton. The continuous current of air in the lint flue takes the lint to a condenser, which separates the lint from the air. The lint is usually delivered from the condenser by mechanical means into the press box, where it is first tramped or packed and then pressed to bale size. The air is exhausted through condenser vents, which should be larger in cross-sectional area than the lint flue in order to effect a satisfactory separation of the cotton and the air.

Cotton is packaged at the gin in two types of containers—the rectangular or so-called "square" bale weighing about 500 pounds and the cylindrical or "round" bale weighing approximately 250 pounds. During recent years about 98 percent of each crop has been packaged in square bales and about 2 percent in round bales. In table 1 is given a description of American cotton bales. Standard or railway-compressed bales and high-density bales are made by compressing the square gin bales. The high-density bale is narrower and more symmetrical than the standard bale.

Approximately 6 yards of bagging, weighing usually 1¾ to 2 pounds per linear yard, is used to cover each except the round bales. After a bale has been sampled, 1 or 2 patches, which usually weigh 3 or 4 pounds each, are generally added. Tare (which includes bagging, patches, and ties) is allowed by southern mill rules up to 22 pounds for the square bale and 24 pounds for the compressed bale, and by New England rules up to 24 pounds per 500-pound bale.[8]

TABLE 1.—*Description of American cotton bales*

Kind of bale	Dimensions (approximate)	Weight (approximate)		Ties, per bale	
		Per bale	Per cubic foot	Usual	Weight
	Inches	*Pounds*	*Pounds*	*Number*	*Pounds*
Square, flat, gin, or uncompressed	54 by 27 by 45–48	500	12–14	6	9
Standard, or railway-compressed	56 by 28 by 18–22	500	25–30	8	9
High-density	59 by 24 by 19	500	32	9	9
Round	35 length, 22 diameter	250	33	0	0

Cotton presses at the gins may be of either single- or double-box and of screw, steam, or hydraulic type, the last being generally considered most desirable. Figure 29 shows a type that is being used increasingly. From 40 to 60 tons pressure is usually applied to the cotton by the press ram in making the square gin bales.

The packaging of American cotton has never been wholly satisfactory either in protecting the cotton or in economy in handling. The materials and methods of covering are controversial subjects. Prevalent practice is to use jute bagging and flat steel ties with a total tare weight of approximately 21 pounds.

PLANNING AND EQUIPPING NEW GINNING PLANTS

The best planned gin is one that is adequate for the needs of the community and its cotton, and yet is capable of the most economical operation commensurate with good service.

Planned capacity for a new ginning plant should be based on the expected seasonal and daily baleage, and should cover the regional needs for necessary additional conditioning, cleaning, and extracting. A plant having four 70-saw stands would gin approximately 26 bales if operating with a loose seed roll or approximately 37½ bales if operating with a tight seed roll in 8 hours of continuous operation—without interruptions such as are common for changing wagons, tying out bales, and the like. This is computed on the basis of 1,500 pounds of seed cotton, satisfactorily dry (8 to 12 percent moisture content), being required per bale of lint. Each gin saw, when operating continuously, would gin out approximately 6 to 8½ pounds of lint per hour from loose and tight seed rolls, respectively.

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[8] For further packaging and tare information see U. S. Department of Agriculture multigraphed report, American Cotton Tare Practices and Problems, April 1933.

Figure 30 outlines six elementary ginning set-ups which incorporate balanced distribution of cleaning and extracting so that the service rendered to the farmer may be reasonably adapted to early clean pickings as well as to late weather-exposed "snaps." Upon the foundation of these lay-outs more extensive or complicated outfits can be developed. It usually will be preferable to add extracting rather than cleaning equipment, if by-pass provisions are incorporated, because the double service of cleaning and extracting is thus obtained with no significant power increase.

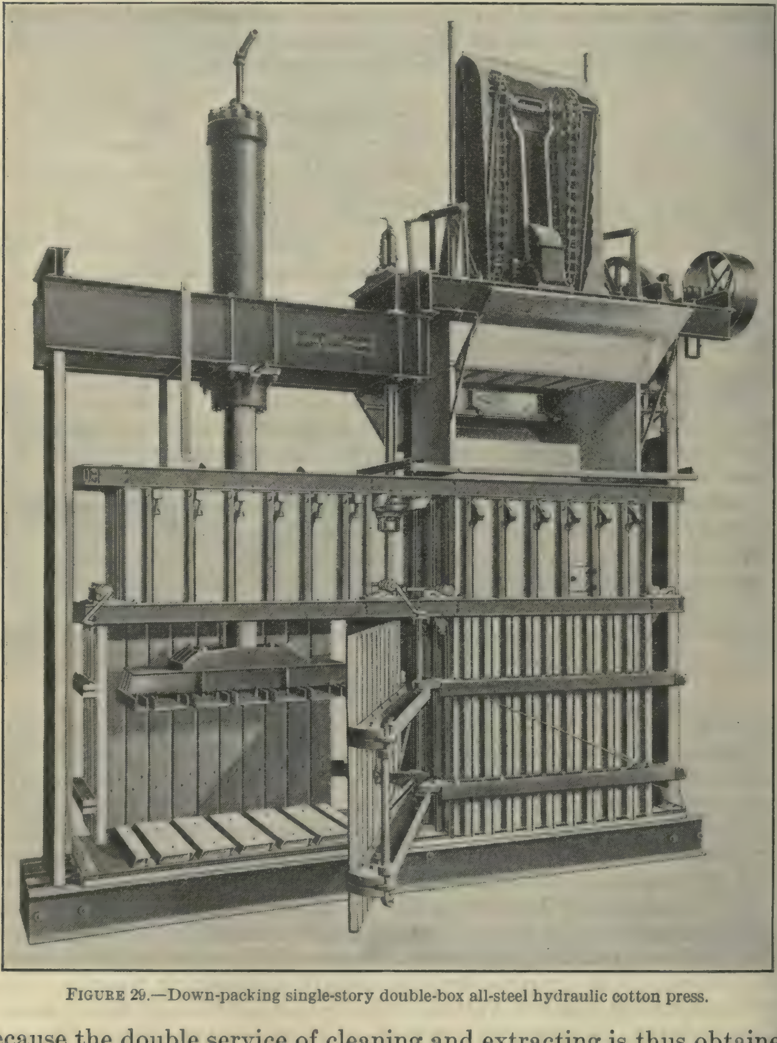

FIGURE 29.—Down-packing single-story double-box all-steel hydraulic cotton press.

Set-ups *A*, *D*, and *F* in figure 30 can be used only in mechanical systems having belt, gyrator, or screw-conveyor types of distributors. Set-ups *B*, *C*, and *E* are suitable for either pneumatic or mechanical systems, set-up *E* being especially suitable for cotton gins in the

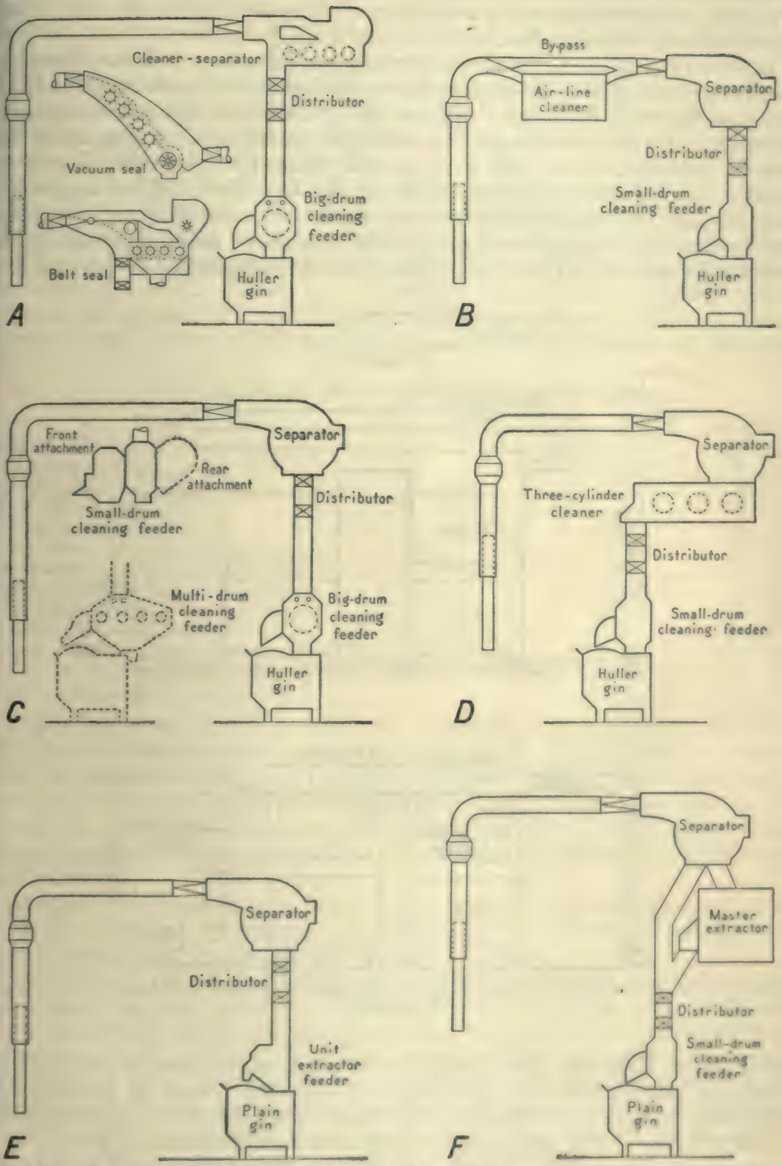

FIGURE 30.—Diagrams of simple ginning systems: *A*, Combined cleaner-separator, distributor, big-drum cleaning feeder, huller gin stand; *B*, air-line cleaner, separator (mechanical or pneumatic), distributor (or pneumatic chutes), small-drum cleaning feeders, huller gin stand; *C*, separator (mechanical or pneumatic), distributor (or pneumatic chutes), big-drum (multidrum) cleaning feeder, huller gin stand; *D*, separator (mechanical only), 3 (or more) cylinder cleaner, distributor, small-drum cleaning feeder, huller gin stand; *E*, separator (mechanical or pneumatic), distributor (or pneumatic chutes), unit extractor feeder, plain gin stand; *F*, separator (mechanical only), master extractor, distributor, small-drum cleaning feeder, plain gin stand.

southeastern area where plain gin stands are still popular. Alternate types of cleaner-separators are suggested in figure 30, *A*, and alternate types of cleaning feeders in figure 30, *C*.

Before final plans for a ginning plant can be made, it is necessary to determine whether a mechanical or a pneumatic distributing or feeding system will be used. Figure 31 illustrates these two general systems. In the mechanical system, the suction of cotton from the wagon is continuous, and any cotton that the gin stands cannot handle immediately is discharged at the overflow. This system is suitable for use with many combinations of conditioning, cleaning, and extracting machinery and is now the more usual system. The pneumatic system is intermittent in its suction from the cotton wagon, and cannot feed the gin stands faster than they handle the cotton. There is no overflow in this type of system, which is not readily adaptable to the use of seed-cotton driers or of cleaners other than the air-line types. The pneumatic system uses a minimum of power, and where only moderately rough cotton is to be encountered it may be used successfully with unit extractors, as indicated in figure 30, *E*.

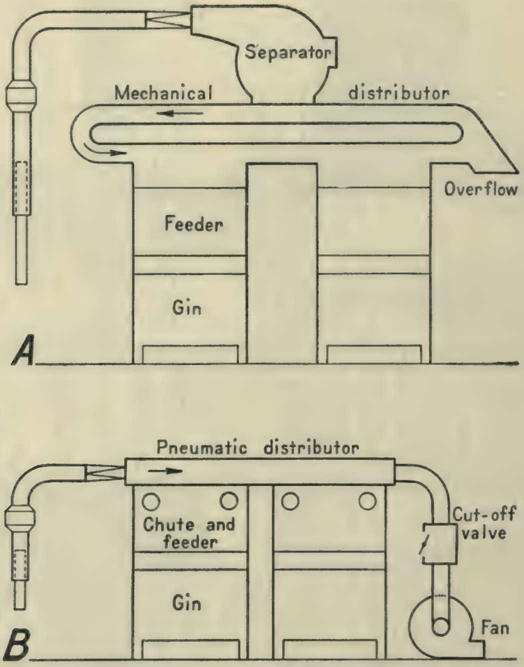

FIGURE 31.—Diagrams of the two different systems of distributing seed cotton to gin stands: *A*, Mechnical; *B*, pneumatic.

The selection of fans, cleaners, distributors, extractors, feeders, etc., will be influenced by the kind of distributing system chosen, but experience indicates that in any case huller gins rather than plain gins should be selected. Double-rib huller gins maintain a cleaner seed roll, are much better adapted to handling both clean-picked and roughly gathered cottons, and usually give samples having qualities equal or superior to those from plain gins. The picker-roller adjustment permits handling varying degrees of roughness in the seed cottons, and the disposal of trash can be accomplished in double-rib huller gins without discharging it into the seed.

The power requirements of ginning-plant equipment can be totaled from the following tabulation, to ascertain what size of motor or engine may be required. It is a serious mistake to choose too small a motor or engine; the power provided may well be 10 percent in excess of the estimated net load. A rough estimate of the total power requirement for an average plant such as those diagrammed in figure 30, complete with fans, feeders, cleaner, separator, distributor, tramper, and hydraulic press, may be made on the basis of one-third horsepower for each gin saw. Thus, a 4–70 outfit (four 70-saw stands) would require an engine or motor having approximately $\frac{1}{3} \times 280 = 92$ horsepower. To be safe, a 100-horsepower unit would usually be selected.

Power required for operating ginning-plant machinery

Machine	*Horsepower*
Fan no. 30	10–15
Fan no. 35	14–30
Fan no. 40	20–40
Cleaner, air line	3½– 5
Cleaner, out-of-air	1½– 5
Distributor	2– 5
Separator	1½– 5
Cleaning feeder	1– 3
Unit feeder-extractor	2– 4
Master extractor	10–20
Brush gin stand, per 10 saws	1. 4– 2. 4
Air-blast gin stand, including air-blast fan, per 10 saws	2. 4– 3. 1
Press and tramper	15–20

Arrangements should be made, if possible, for an all-steel building of fireproof construction, one story high, with a bale crane, a wagon shed, and a seed conveyor to adjacent seed storage. Ample headroom should be allowed for driers and any future overhead equipment. It is best to locate seed scales in the ginning building, and to place them where the scale beams are easily accessible to the ginner and yet fully protected.

Engines and fans should be preferably in a separate compartment from the ginning machinery, to eliminate noise and to protect the power machinery from grit and dust.

Many good plans for ginning machinery have been worked out by manufacturers and ginners. Figure 32 shows the floor plan for a one-story electrically operated ginning plant for use by the United States Department of Agriculture. The cotton house and seed house may be included in a straight line or grouped in a cluster to suit local conditions. There are many good features about this plan that are desirable at any ginning plant, such as ample working space about the machinery, single-floor operations, and adequate headroom.

All gins, particularly in dry areas, should be grounded by adequate wiring to prevent fires caused by static electricity.[9]

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[9] See Circular 76, Fires in Cotton Gins and How to Prevent Them.

CARE, MAINTENANCE, AND OPERATION OF GINS

Certain operating practices and precautions are important from a ginner's standpoint. The spring and summer work that should be done preparatory to ginning include the inspection, repair or replacement, and adjustment of such items as saws, ribs, picker-rollers, brushes, air-blast nozzles, cotton piping, air-blast piping, lint flues and condensers, fans, cleaners, extractors, distributors, seed elevators, seed conveyors, press rams, and pumps.

The gin plant should be thoroughly cleaned at the beginning and periodically throughout the ginning season—say after each 50 bales have been ginned—and it should be left clean after the final shutdown to eliminate fire and other hazards. The saws should be left in such condition that they will not rust. It is a bad practice to loosen the rust with kerosene and then remove it with the cotton of the first patron. This and the practice of applying kerosene to saws that have been gummed up in ginning wet and dirty cotton have caused complaints from spinners of cotton. Artificial drying prevents annoyance from ginning wet seed cotton.

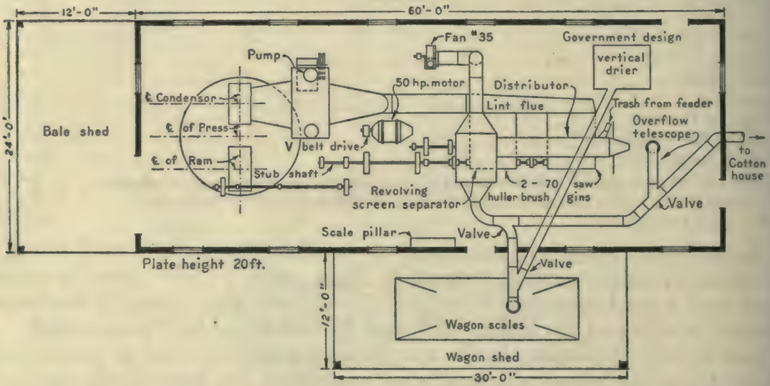

FIGURE 32.—Plan for one-story cotton ginning establishment to be used by Department of Agriculture.

Distributors are frequently sources of trouble, especially in wooden buildings which may settle or become warped. If the distributor is braced by horizontal stiff-arms straight to the wooden walls, the distributor will often be pulled out of line so much as to the cause the upper portion to serpentine in one direction while the lower part twists in the reverse. Weights of cleaning machinery, when partly supported by the distributor, may still further aggravate this twist and misalignment. These factors cause the distributor pulleys to wear off at one place faster than another, and cause the belt spikes to be ground off on the underside of the belts when the pulley grooves disappear, so that the spikes fall into the machinery.

It is good practice to sharpen the gin saws after every 500 to 1,000 bales, depending on the severity of the work. If the teeth of the saws become dull, worn, broken, or out of shape, the ginning capacity is reduced, and the seed roll becomes tighter because both the ginning and lint-doffing actions are impaired. The fibers that are not cleared, or removed from the saw teeth, accompany the saw through the roll ox again and cause additional napping of the lint. They also ncrease fire hazards. The moting action of the gin is impaired under hese poor ginning conditions. When saws are not adequately epaired and properly trained, there is danger that they will "drag" he ribs, which causes wear on both saws and ribs. Lack of alignment nd clearance further injure the quality of the sample, and cause dditional fire hazard. Gumming and filing should be done in such a way as to keep the saws circular, and with the factory pitch. The eading edge of the tooth should be practically parallel to the surface f the main ribs at the position where the teeth pass through with the int. This edge of the tooth should have no burs, and should be neither round nor rough, and the tooth should taper from base to point. Some ginners prefer to gum the saws with a machine and then finish dressing the teeth by hand with a flat file.

The ribs should be replaced or repaired if worn, so that they have clean, straight edges with the sharpness barely removed. The saw slots should be approximately three saw thicknesses in width, 0.125 inch being considered a maximum allowable and 0.117 inch being about the average for a factory job. If ribs are allowed to become badly worn, both the ginning capacity and the quality of the sample are reduced. The ribs can become so badly worn that seed will readily pass through the rib space or slot along with the lint, and cause the undesirable addition of seed to the ginned lint. Under these conditions chokages and fire hazards often result. Ribs can be repaired by building up worn places by arc welding and then grinding to obtain new surfaces. Ribs can be cadmium plated, painted, or greased to prevent rust. At the end of a season, the ribs and saws should be oiled with crude oil or other protective lubricant. When the ginning begins, kerosene or white gasoline should be used to remove this protective coating.

Picker rollers should be checked for missing spikes, and should be properly aligned so that the spikes are centered between saws. During the early part of the season, when clean hand-picked cotton is being ginned, the picker roller should be near enough to the huller ribs to prevent any good locks of cotton from being expelled but far enough away to avoid chokages. Later in the season, when rough cotton is encountered, the picker roller should be moved away from the ribs in order to give a better discharge of the burs and other foreign matter. The distance the saws protrude through the huller ribs is important and should be checked against factory settings.

Brushes should be protected from vermin and rodents during idle seasons, and before being used should be refilled with bristles where necessary and then balanced. This will insure adequate and uniform doffing, and will contribute to smooth ginning. Ball-bearing balancing rigs or knife edges may be home-made by the ginner, if he is familiar with the ways and means for such work, but factory repairs are generally advisable.

For saw speeds between 400 and 550 revolutions per minute, with 12-inch saws, the peripheral speed of the brushes should be approximately 6,666 linear feet per minute. This figure, 6,666, is easily remembered.

All operators of brush gins should give attention and periodical inspection to the wind boards that are placed between the upper parts of the saws and the brushes. It is important that the position and proportions of this dividing board be maintained. Some manufacturers provide their patrons with cheap metal covers to do this when the board shows signs of wear. If the board is not protected or replaced when its position has been affected by wear, it will change the volume and direction of the brush blast upon the saws. It may seriously affect both the doffing and the moting actions, and it thus becomes a potential menace to making good samples. Likewise, the backboard, which is above the brush at the back of the gin stand, must be kept free from wear, and it should be kept sufficiently close to the brush tips to prevent the accumulation of "fly" and lint in a wad or mass above the brush.

Air-blast nozzles not only should be given occasional inspection to assure correct position and freedom from chokage, but also should be tested with a U-tube water gage during operation of the gin in order that correct doffing pressure may be maintained. In practice the nozzle position is about one-eighth inch or more from the tips of the saw teeth, and the pressure should be from 10 to 16 inches water gage depending on regional conditions and types of cotton handled.

All cotton piping, lint flues, adapters, and fan connections should be airtight and unobstructed. Leaky joints can be repaired cheaply by using strips of adhesive wrapping tape of heavy manila paper. Fans should be very carefully checked with regard to condition of wheel, speed, pressure, and operating factors. Air volumes delivered by fans vary directly with the speed, and driving power for fans varies as the cube of the speed; hence the conditions for best and most economical operation are not likely to be obtained by chance but should be worked out to suit each individual installation.

Backlash frequently results from excessive pressure in the lint flue, which may be caused by too high speeds of the air-blast fan or the brushes or by too small a condenser. This in turn may result in trouble with the gin stand at one or the other end of the battery.

Seed elevators and conveyors should be of the screw or belt type, in preference to seed-blowing devices which are inefficient and more costly in operation.

Press rams should be properly packed at reasonable intervals, and petroleum oils rather than water should be used as the hydraulic fluid. Although such oils involve a slight expense, they prevent corrosion and protect the polished plunger surfaces and the working parts of the pump.

Care of the buildings and premises to avoid roof leaks, to protect the machinery, and to prevent serious fire hazards by frequent removal of all clinging lint and dust, is essential for the good gins of today.

Belts should be removed at the end of the ginning season, rolled up, and stored in a dry, protected place until wanted again. If V-belts cannot be readily removed, the tension in them should be released during the idle period.

Stock bolts, shafting, small tools, etc., should be protected with a thin film of oil, preferably by being dipped in a mixture of lubricating oil and gasoline.

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U. S. DEPARTMENT OF
AGRICULTURE
FARMERS' BULLETIN No. 1749

Slightly rev. Jul 1940

MODERNIZING FARMHOUSES

OLD FARMHOUSES that are sturdy and sound can often be brought up to modern standards of comfort, convenience, and appearance for less than the cost of a new house. This has been done with surprisingly small outlays of cash where the farmer has contributed considerable portions of the materials and labor from sources available on the farm.

The present time (1935) is especially good for making home improvements. The Federal Government has arranged for special loans for home improvement; the Department of Agriculture is cooperating with the State colleges to provide plans and other information helpful in making such improvements; and expenditures for materials and labor will help to bring about recovery. Consideration of past social tendencies and present economic conditions suggests that farm people can obtain greater satisfaction if a larger part of their income than heretofore is used for better housing rather than for expanding the farm business.

The Farm Housing Survey made in the spring of 1934 by the United States Department of Agriculture, in cooperation with the agricultural colleges of 46 States, collected information on the condition of farmhouses in 352 counties, some records of remodeling work done, and costs of repair and remodeling operations. This bulletin presents examples of modernizing that have been accomplished, alternate plans for some of these situations, and plans for some typical conditions not represented by the other examples.

Publications of interest to persons planning house repairs include:

Farmers' Bulletins:
- 1087, Beautifying the Farmstead
- 1219, Floors and Floor Coverings
- 1227, Sewage and Sewerage of Farm Homes
- 1279, Plain Concrete for Farm Use
- 1426, Farm Plumbing
- 1448, Farmstead Water Supply
- 1452, Painting on the Farm
- 1572, Making Cellars Dry
- 1590, Fire Protective Construction on the Farm
- 1638, Ratproofing Buildings and Premises
- 1649, Construction of Chimneys and Fireplaces
- 1660, Logs and Poles in Farm Construction
- 1698, Heating the Farm Home
- 1720, Adobe or Sun-dried Brick for Buildings
- 1738, Farmhouse Plans (10 cents)
- 1751, Roof Coverings for Farm Buildings and Their Repair

Leaflet 101, Injury to Buildings by Termites
Department Circular 405, The Domestic Oil Burner (10 cents)
Circular 335, Distillate Burners

Department of Commerce Publication 15, Care and Repair of the House (15 cents)

Department of Commerce Bulletin, House Insulation (10 cents)

The above publications may be purchased from the Superintendent of Documents, Washington, D. C.; the price is 5 cents (cash, not stamps) each, except as otherwise stated.

Washington, D. C. Issued November, 1935

ERRATA, FARMERS' BULLETIN 1749 (NOV. 1935)

age 5: In line 43, "Figure 47" should be "Figure 35".

age 7: In line 2 from bottom, "house 11" should be "house 12".

age 10: In line 5, "(fig. 41)" should be "(fig. 43)".

age 17: In line 2 from bottom, "46" should be "40".

age 24: In line 25, "p. 42" should be "p. 44".

age 37: In legend for figure 35, "house 8" should be "house 7".

age 40: Under heading "House 10 (Nebraska)", first line should read "Before remodeling, 5 rooms; added 2 bedrooms, bath, and basement; cash".

43586 G P O

Planning the improvements 19
Putting the plan on paper 19
Selection of materials 20
House 15 (North Carolina) 52
House 16 (Illinois) 55
House 17 (Massachusetts) 57
House 18 (Michigan) 60

INTRODUCTION

MANY FARM FAMILIES, even under the handicap of depression years, have undertaken home improvements. They wish to correct such things as crowded quarters, awkward arrangement of rooms, too many steps to go up and down, out-of-date water supply, bad lighting, rough floors, or a run-down condition in any part of a house. This bulletin is intended to help such families plan the changes that may be needed.

Improvements can be made a step at a time, as income and farm work permit. Often the work can be done by members of the family, with materials obtained in the neighborhood. With little or no cash outlay for labor, and with lumber, brick, stone, slate, sand, and gravel from nearby, or with adobe, where the earth is suitable, the cash required should be hardly half as much as if both labor and materials were obtained at commercial prices.

Sometimes, of course, there will be a question whether to remodel or to rebuild. Is the old house itself still sound enough to warrant spending time and money on it? Even if it is not sound, has the house associations too precious to lose by its destruction? Is not the cost of modernizing some of the old farmhouses, especially along the eastern seaboard and in sections of the South, even though as great as the cost of a new one, worth while if it will preserve a historic landmark or save the traditional charm of some old family homestead?

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[1] The assistance of the Farm Housing Survey workers who gathered the material used in this bulletin and the kindness of the farm families and local builders who made the information available are hereby gratefully acknowledged.

APPRAISING THE OLD HOUSE

The condition of the old house and the cost of putting it in good repair should be checked by a competent builder as the first step in planning improvements. This frequently shows ways of combining the repair and remodeling work to greater advantage.

Unavoidable interference with the use of the house during building operations may be minimized if a temporary kitchen or sleeping quarters outside the house are available during the building period, or if persons not needed at home can spend the time elsewhere.

If a change of location[2] seems desirable because of an inconvenient or unfavorable location as regards main roads and fields, or poorly placed, run-down buildings, neither extensive remodeling nor new building should be considered, but the installation of equipment that can later be moved to a new house may be feasible.

ELEMENTS OF MODERN HOMES

When a house is to be modernized, first consideration should be given to the three principal home utilities—pressure water supply with plumbing and safe disposal of wastes, a lighting system, and a heating system. The plans should provide for these utilities, even though they may not be installed at first.

Other desirable types of improvements are additions of needed space, arrangements for storage, weatherproofing and insulation, resurfacing of floors, and refinishing of walls. Changes in the arrangement of doors, windows, partitions, and stairs often add greatly to the convenience and appearance of a house. If it is not feasible to make all the alterations at one time, they should be planned so the work may be done in logical order and with little duplication.

WATER AND PLUMBING

A kitchen sink is probably the most useful single home convenience. A suitable one may be bought and installed for $12 to $25 complete with drain. It is frequently the first step in a lay-out that grows step by step into a complete plumbing system. The second step might be a hand pump at the sink, piped to draw from a nearby cistern or shallow well. The pump can be connected also to a boiler heated by the kitchen range, with a simple valve arrangement to permit pumping either cold or hot water as desired. Later the hand pump can be replaced by a power pump and pressure supplied from an elevated tank or from a hydropneumatic (water-air) tank. A bathroom and septic tank can be added when finances permit.

A hydropneumatic water system may be placed in the cellar if the water is drawn from a cistern or shallow well near the house. If the water is deep the pump cylinder must be in the well, with headroom above for lifting the pump and pipes for repairs. A good location for a deep well is 4 to 8 feet outside the house in an extension of the cellar, with a trap door above to permit lifting out the pipes.

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[2] Small or medium-size farm buildings can be lifted with jacks or levers, mounted on skids, and hauled with teams, tractors, or cable and winch. Heavy tractors of the type used for road grading are best for such work. Frozen ground favors hauling, and greased skids or rollers lighten the draft. Buildings that cannot be moved profitably have salvage value, especially if the wrecking work can be done at slack times.

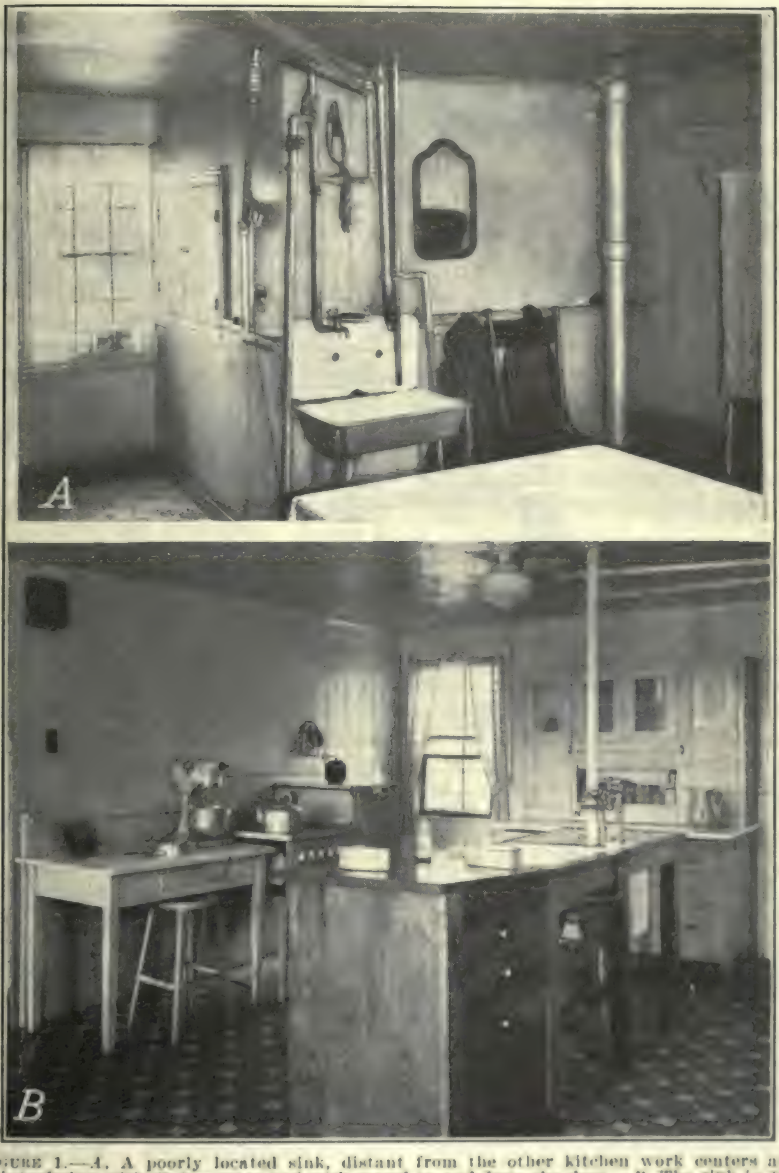

FIGURE 1.—*A*, A poorly located sink, distant from the other kitchen work centers and interfering with dining space and with travel to and from the door. *B*, The sink in the same kitchen centrally located after remodeling. Drawers under the drain board open from either side; the coal range is at the right.

The kitchen sink is an important work center and should be located advantageously. If far from the work table, stove, and storage cabinets it is not very useful (fig. 1, *A*). A central location (fig. 1, *B*) is sometimes best in large kitchens. A good arrangement places the sink between the drain board and work table, with cabinets convenient, in a well-lighted location (fig. 2). Materials for drain boards and shelves cost little and these conveniences can be made by any man handy with tools. A large sink, 20 by 30 inches, will hold a dishpan and dish drainer at one time.

A lavatory or wash sink near the back door so that the men can wash before entering the house helps to keep out dirt. In warm climates the lavatory may be placed on the back porch. There should be hooks nearby for hanging outer wraps.

The bathroom should be located convenient to all parts of the house, especially to the bedrooms; unless there is more than one bathroom it should not open into any bedroom. A stationary bathtub with running water, or even a shower, is desirable, and an indoor toilet is conducive to the health of all the family especially the old, the ill, and the very young. A toilet requires a 3-inch pipe stack connected to the sewer below and extending up through the roof, and it should be placed so that the stack can be located in partitions or in unused corners of the rooms above and below.

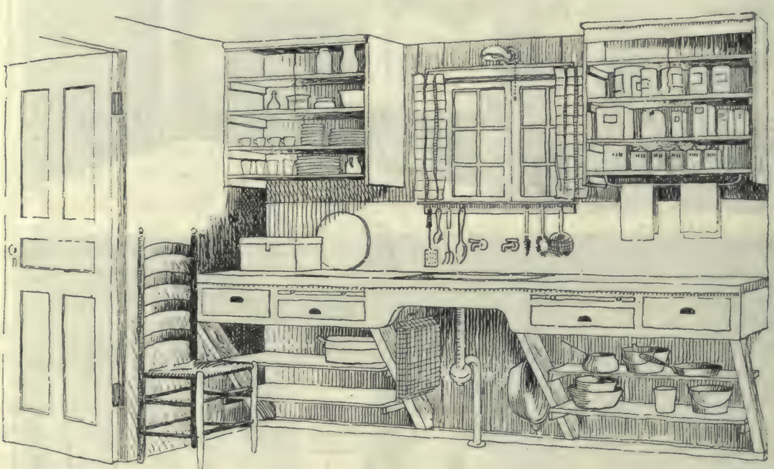

FIGURE 2.—An inexpensive installation of sink with home-made cabinet, drain board, and shelves. Roller shades are used instead of doors on the cabinet. Doors to protect utensils on the lower shelves could be provided at small cost. (Department of Agricultural Engineering, University of California.)

Costs of various plumbing installations as reported by the Farm Housing Survey are given in the following tabulation. The figures are for simple types of equipment, and include the value of the work performed by the farmer as well as his cash outlay.

Item of improvement:	*Cost, installed*
Pitcher pump in house, connected to cistern or shallow well	$12 to $18
Hand force pump with storage tank and piping, connected to cistern or shallow well	40 to 75
Pressure water system with electric pump, connected to cistern or shallow well	95 to 150
Kitchen sink with drain only	12 to 25
Kitchen sink with connections to water and sewer systems	20 to 30
Range boiler with water back	20 to 30
Septic tank with house sewer and distribution tile	35 to 60
Indoor flush toilet with water connections, stack, waste, and vent piping	40 to 70
Lavatory with water, waste, and vent connections	20 to 30
Bathtub or shower with water, waste, and vent connections	40 to 70

ELECTRIC POWER

Electricity has many advantages for lighting, for refrigeration, for operating washing machines, irons, vacuum cleaners, and radios, for cooking, for heating water, and for other purposes. Electricity also makes possible automatic water systems and thus contributes to the use of plumbing.

Cost of connection to a power line varies with the distance of the house from the power line and the policy of the power company. The Farm Housing Survey reported the costs of connections and house wiring together as ranging from less than \$100 to more than \$500. In some of the Western States, where large amounts of electricity are used for pumping water for irrigation, the average consumption per farm in 1929 was 7,080 kilowatt-hours, and the average charge was 1¾ cents per kilowatt-hour. The average use per farm in the remainder of the United States was only 746 kilowatt-hours per farm, and the average charge 8⅙ cents per kilowatt-hour. These figures give a good idea of the relation of large use to low unit cost.

Individual home lighting plants are generally satisfactory, though less so than connection to a power line on account of limited capacity and need for servicing. Some types supply 115-volt, 60-cycle alternating current, the same as that from most power lines, so no change in motors is needed when transfer is made to power-line current. Proper wiring for an individual plant requires little change for power-line service. An individual lighting plant with house wiring usually costs, installed, from \$200 to \$500, according to the capacity.

Electric wiring is installed best by skilled workmen, but many farmers have done satisfactory jobs on their own houses and other farm buildings.[3] The cheapest electric light wiring provides merely a ceiling fixture in each room, with the current turned on and off by a pull cord from the light socket. A connection for a washing machine or other electric appliance can be added by dropping a cord and socket from the light wires. The wiring may be of the " knob and tube " type or may make use of metal- or fabric-covered cable, and may be either exposed in the room or concealed in the hollow spaces of the wall and ceiling. Concealed wiring is desirable for the sake of appearance, though metal- or fabric-covered cables carefully placed and painted to match walls and ceilings are not especially noticeable. Materials and fixtures for the simplest system need cost only about \$2.50 per room.

If a larger investment can be afforded, wall switches for the ceiling lights and an abundance of convenience outlets in the walls for plugging in portable lamps and other appliances are recommended. Figure 47 shows a moderate-cost lay-out of lights and convenience outlets for a typical farmhouse. There is a central light in each room, and a duplex convenience outlet or socket in the baseboard between each pair of doors so that portable lamps or other equipment can be plugged in. Bracket lamps are recommended beside the shaving mirror in the bathroom and over the kitchen sink. In the larger rooms the central light is controlled by a switch near the door. The light in the hall over the stairway and the light over the basement stairs are controlled by three-way switches so that the light can be turned on or off from either the top or bottom of the stairs. A fixture to light the driveway and path to the barn might be mounted either on the side of the house or on a pole out of doors. It also would be controlled by three-way switches, one at the back door and the other at the barn.

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[3] Instructions are given in Extension Bulletin 204, Electric Wiring for the Farm, issued by Cornell University, Ithaca, N. Y., and costing 20 cents per copy outside of New York State. Instructions on wiring may also be obtained from some State experiment stations and some dealers in wiring materials.

A few suggestions for locating lights and conveniences are the following: Put a switch on the lock or knob side of a door; locate outlets so that the cord to a lamp or other appliance does not have to be pulled across a doorway; place a light so that it throws no shadows on your work or on stair steps; use insulated sockets and pull cords near plumbing fixtures to avoid danger of shocks.

Good lighting depends on plenty of light without glare. In general, lamps that throw only a small spot of bright light without illuminating the rest of the room are not desirable.

IMPROVED HEATING

Farmhouses may be heated by fireplaces, stoves, circulator heaters, or central heating systems circulating warm air, hot water, or steam. The so-called " pipeless (one-pipe) furnace " and the piped warm air, steam, and vapor systems as ordinarily used in domestic heating require cellars, and for a hot-water system a cellar is desirable though not necessary.

A fireplace gives out radiant heat that warms persons and objects without raising the air temperature and lowering the relative humidity as much as do other ordinary heating systems. Some authorities regard the use of radiant heat as more healthful than other methods of heating. A large part of the heat from a fireplace passes up the chimney and is lost, but this loss is less in certain commercial types of fireplaces that have metal backs with provision for circulating heated air into the room.

Stoves utilize fuel more efficiently than do fireplaces. In cold climates a stove is needed for each 2 or 3 connecting rooms, or for each room if the doors between are kept closed. Chimneys must be so located that proper flue connections can be made. Ordinary ranges, cookstoves, and laundry stoves will usually warm the rooms in which they are placed.

Circulator or parlor heaters have metal jackets, which increase the circulation of air in the room and give better distribution of heat than is obtained with ordinary stoves. The larger sizes warm 2 to 4 connecting rooms satisfactorily. These heaters harmonize better in appearance with other furniture than do stoves, and the comparatively cool outer surface is less likely to burn children or clothing. Circulator heaters that burn kerosene or the lighter distillate oil fuels reduce the labor and muss of caring for the fire. In most sections the cost of these fuels is higher than that of coal.

Central heating systems well designed, installed, and operated give uniform and easily controlled temperatures in all parts of the house where heat is wanted. Such systems require less attention than stoves, and if placed in the cellar or in a special heater room they avoid dirt and muss in the living quarters. They burn various grades of anthracite, bituminous coal, coke, or chunks of wood, and may be fitted with gas or oil burners. Since they heat the house more completely than stoves, they usually burn more fuel. The selection and location of heaters for the modernized houses shown in this bulletin are discussed in connection with each plan.

Reports from the Farm Housing Survey indicate that the ordinary costs of heating equipment, including installation, are about as follows:

Item:	*Cost per room*
Circulator heaters	$10 to $20
Pipeless furnaces	20 to 30
Piped warm-air furnaces	35 to 45
Steam systems	50 to 75
Hot-water systems	60 to 85

The survey figures did not show much variation for different parts of the country. Apparently differences in climate are largely offset by use of smaller rooms, lower ceilings, and warmer house construction in the colder regions. Steam and hot-water heating systems are little used in the warmer areas.

ADEQUATE PROTECTION FROM THE WEATHER

Houses lacking tight construction and hence hard to heat may often be greatly improved in this respect at a small cost for materials and a moderate expenditure of family labor. Leakage of air around windows and doors, which causes great loss of heat in many houses, can be almost stopped by the use of weather-stripping, or by tightly fitted storm windows and doors, which also cut down the loss by forming dead-air spaces. The material for the cheapest kind of weather-stripping costs only a few cents per door or window.

Many houses have openings between the wall studs from the cellar to the attic. Such construction is wasteful of heat and adds to fire risk, for if a fire should start in the cellar the open spaces between the studs would act as chimneys to spread it over the whole house. Warmth and safety are increased by closing these spaces, for which pieces of plank, bricks, tin, or plaster on metal lath may be used in the cellar (fig. 3) where most fires start. Insulation board, which is easily cut and fitted, answers well for closing the spaces at the top. House walls may be made very warm in winter and cool in summer by filling the stud spaces with fill insulation.

Large losses of heat occur through unprotected ceilings and attic walls. Fuel savings can be made and comfort improved by applying fill insulation over the ceiling or by laying sheet insulation or tight flooring on the joists. All openings should be closed to prevent drafts of cold air reaching the ceiling. Sheet insulation can likewise be used to advantage on the backs of walls next to cold spaces, as on the walls of the upper rooms in a story-and-a-half house. The same insulation that protects from cold in winter aids in keeping the house cool in summer. For summer comfort, insulation should be supplemented by cross ventilation of the rooms and ventilation of the unused spaces under the roof. New and comfortable bedroom space can sometimes be provided economically in the attic, as in house 11, by insulating the roof and providing for cross ventilation.

SATISFACTORY LIVING SPACE

In the majority of cases, the remodeling of a farmhouse involves building an addition to increase the amount of living space. Some instances involve merely an addition to or rearrangement of partitions for the greater convenience of the occupants, or the dividing of a large house to accommodate two families. The trend is toward larger living rooms than those provided in the older houses and fewer bedrooms than were desirable in the days of larger households.

To better adapt the house to present requirements, the living room is enlarged—or added—in most remodeling undertakings and made more attractive. But because the living room needs to be centrally located it is usually given space in the old part of the house, while the addition is most often made a bedroom to replace sleeping space taken for the living room, a bathroom, a hall, or closets. Studies of kitchen work and the use of modern equipment have resulted in much more compact and efficient arrangements for the kitchen, where modernizing seldom requires additional space but frequently necessitates moving doors or windows.

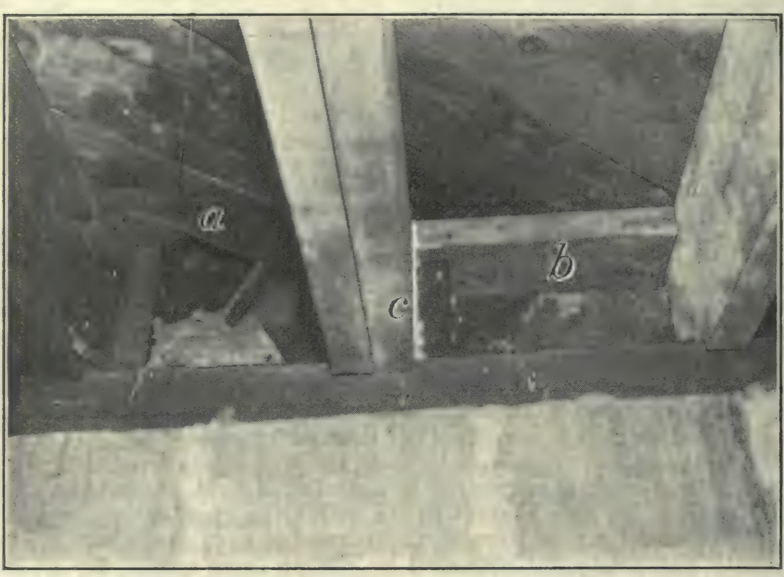

FIGURE 3.—Stopping openings to stud spaces: *a*, opening left by builders, with plaster fallen through; *b*, piece of 2 by 6 tightly fitted to close opening; *c*, rock wool used to calk cracks.

CELLARS

In cold climates a dry cellar is the best place for the heating plant and fuel. A space 12 by 15 feet will accommodate them. A good cellar is also very useful for storing fruits, vegetables, and canned goods, and is sometimes the best place for the laundry and the water system or lighting plant. A cellar under part of the house will often provide all the room needed.

Hillsides offer unusual advantages for cellars, if protected from seepage. Little excavating is necessary, and doors and windows can be located to make the cellar an ideal workroom. Under favorable conditions the kitchen and dining room may be located there, or the space may be used for a play room. If the heating plant is in the cellar, plaster on metal lath under the first-floor joists and under the stairs to the second floor helps to prevent serious fires. Sewer lines for future plumbing should be laid before a concrete floor is put in.

When a cellar is to be built under a house the house may be supported as shown in figure 4. A number of timbers and jacks are needed if the structure is to be raised. Otherwise timbers should be blocked, wedged, or jacked into place to hold the weight but not raise it. Raising the house unevenly or allowing it to settle is likely to crack plaster. The earth may be removed with a slip scraper drawn by a long chain or rope, or with a wheelbarrow. If the work is hired and all materials purchased, cellars for new farmhouses usually cost 50 cents to $1 per square foot of floor space, and cellars dug under existing buildings cost somewhat more.

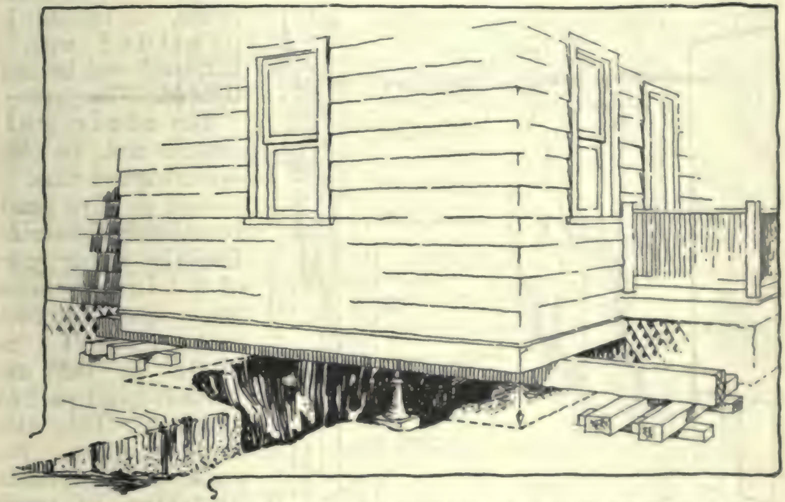

FIGURE 4.—Method of supporting house on timbers and jack during excavation of cellar.

CLOSETS

There should be one or more closets for each bedroom (fig. 5), a linen closet in or adjacent to the bathroom, a broom closet near the kitchen, and a closet or at least hooks on the rear porch or in the rear entry to provide for hanging outer work clothes. A closet in the hall or living room is convenient for coats and visitors' wraps.

GOOD STAIRS

Many stairs can be greatly improved by hand rails and better lighting; the only satisfactory remedy for others is complete rebuilding. Sometimes an entirely new stair location is demanded (see house 15). The expense of tearing out an old stairway and rebuilding will often pay for itself many times over through the advantages gained in room arrangement. Various types of stairs are commonly used in farmhouses; that with grade entrance and landing (fig. 41) is very good where there is a cellar.

A much-used stairway should not be steeper than a 7½ inches rise in 10 inches run (fig. 6), though 8 inches rise in 9 inches run or 9 inches rise in 8 inches run often is used to cellar and attic. Stairs should be not less than 3 feet wide. One may stumble on winding stairs, and it is difficult to move furniture up and down them. If a winding stairway must be used, on account of limited space, it should be provided with a handrail and be well lighted.

The stair well should not be left open higher than is needed to give headroom over the stairs. Use the upper part of this otherwise waste space for bedroom closets as shown in the upper left-hand part of figure 6. This also saves needless expense and trouble in trying to reach the upper part of a high stair well when papering or cleaning.

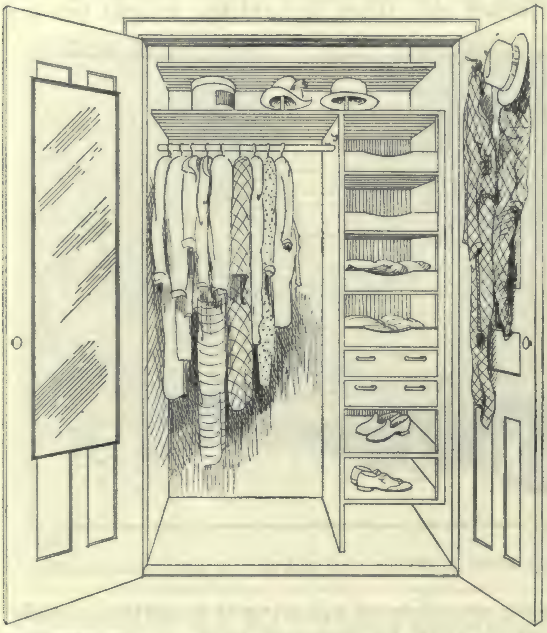

FIGURE 5.—A well-designed closet. (Oregon State Agricultural College.)

WELL-FINISHED FLOORS, WALLS, AND CEILINGS

Smooth, tight, well-finished floors are easily kept clean. Floors streaked with splinters or deep grooves should be sanded smooth. If the condition is too serious, lay a new floor over the old. This also adds stiffness to the floor. There are many satisfactory varieties of wood, and linoleum is well liked for many purposes. Concrete is often used for workrooms and porches, and there is a patented method of placing a thin concrete wearing surface over old wood floors. There are also several new manufactured flooring materials which deserve consideration. Choice will depend to a large extent on local supply and price.

If new floors are to be laid, make them level. An old floor out of level because of the settling of walls or girders often may be corrected by jacking the girder back to place or by wedging under the ends of the joists. A sagging floor can usually be given a level surface by using long shims nailed in place under new flooring, or blocking can be used, as illustrated in figure 7, when the old floor is badly out of level.

Interior walls and ceilings may be repaired and refinished in a number of ways. When only a small area of plastered wall or ceiling needs repair, the work can often be done by the owner. Ready mixed plasters are convenient for this purpose.

Repairing or replacing a large amount of plaster causes much dirt and disorder. Covering the old wall with a new surface may therefore be desirable. Gypsum sheets, wall board, insulation board, plywood, wood boards, or metal sheets may be used, each having certain advantages of utility or price. Where protection from heat, cold, or noise is a consideration, insulation board has an advantage as an interior finish, especially on ceilings or the upper parts of walls where it is not subject to mechanical injury. A wainscot of horizontal or vertical boards may be used on the lower parts of the walls. Insulation board on the lower parts of walls should be protected by gypsum plaster or other hard surface; lime or cement plaster is not suitable.

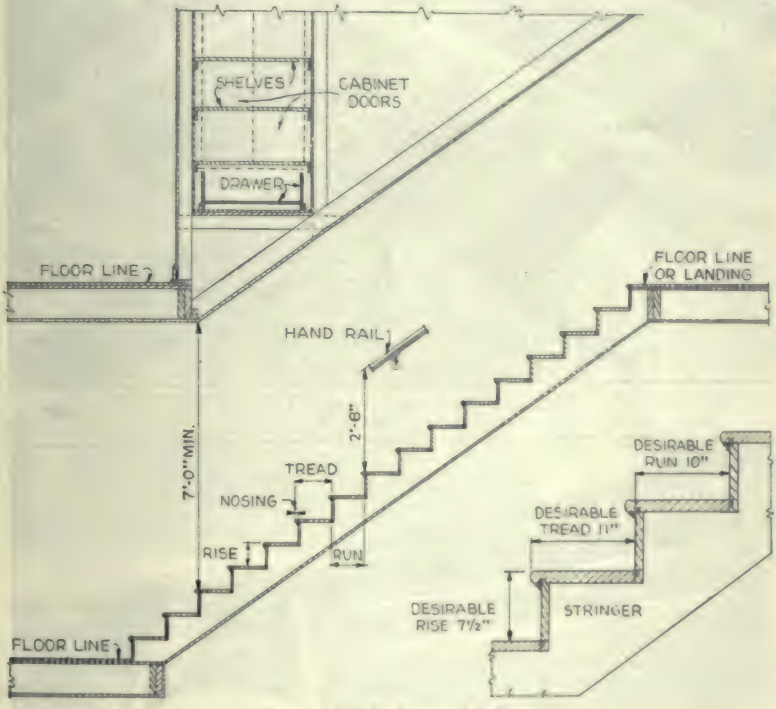

FIGURE 6.—Stairway details.

When applying these materials over old plastered surfaces, all loose or badly broken plaster should be removed. It is best to apply the sheets over 1 by 2 inch wood strips spaced to fit the material but not more than 16 inches apart (fig. 8). These strips can be securely nailed to the joists through the plaster with eightpenny nails, and should be shimmed to provide a level base for the new surface.

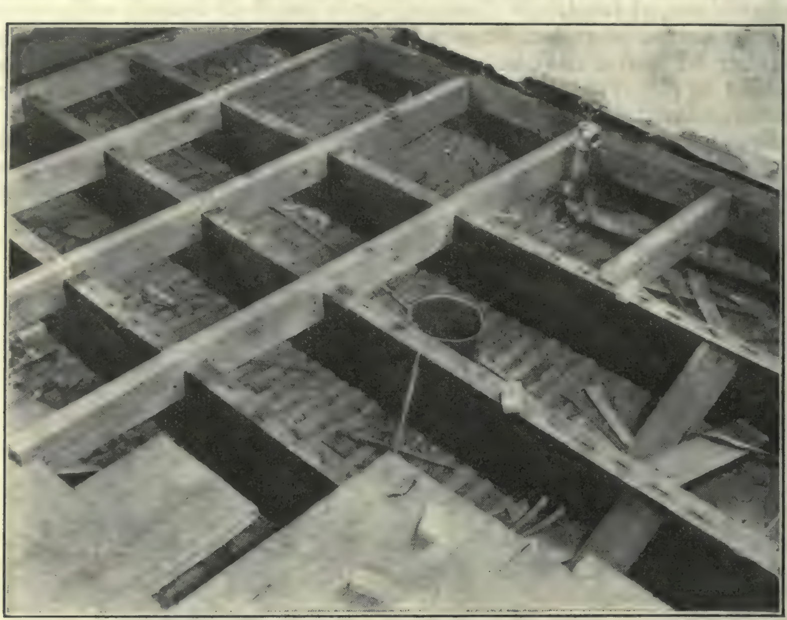

FIGURE 7.—Leveling floor with blocking.

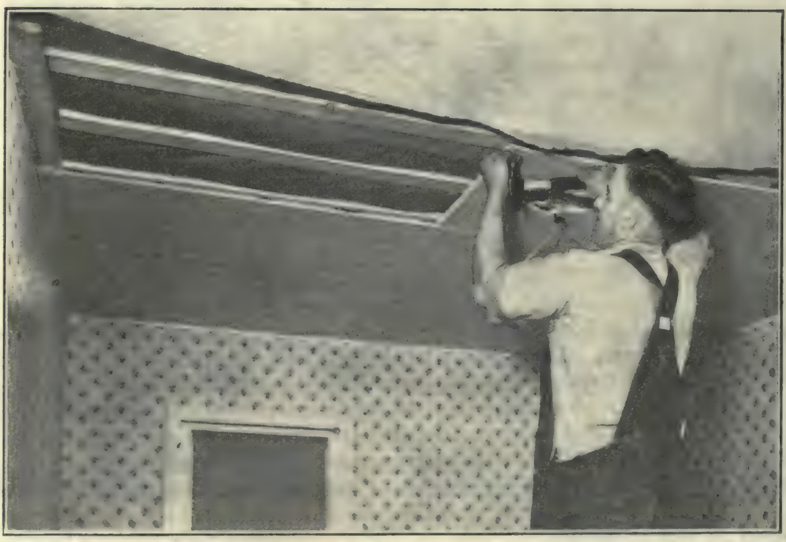

FIGURE 8.—Insulation board being applied over plastered ceiling, with wood strips to give nailing base, and sound-deadening material used next to old plaster.

Some insulation and composition boards are made to give tiled or paneled effects, and the joints are part of the decoration, as illustrated in figure 9. Some of the boards are finished at the factory and do not require painting on the job. When large plain sheets are used, attention must be paid to the joints, since most of these materials will shrink and expand a little. Manufacturers' instructions should be followed. Joints may either be covered with strips or be left open about one-eighth inch. In either case the sheets should be arranged in regular patterns. When wide boards are used as an interior finish, the edges may be beveled or may be covered with battens for decorative effect.[4]

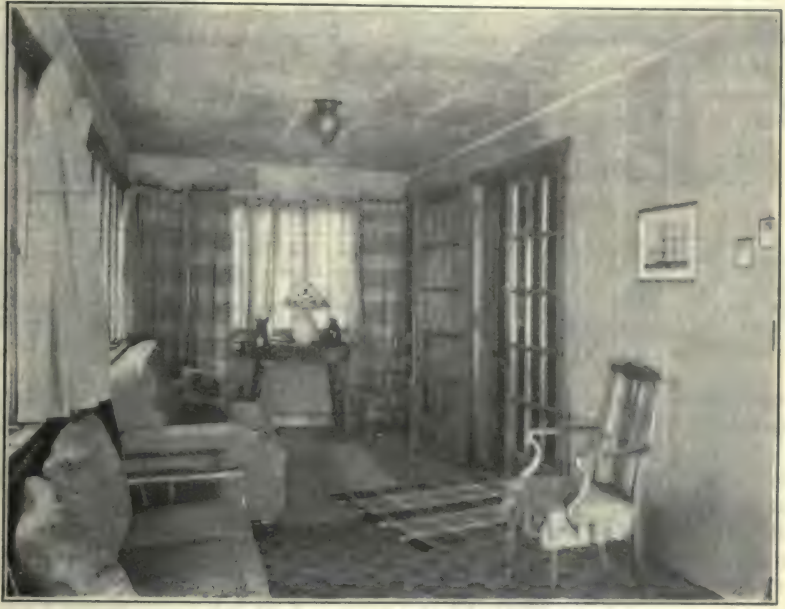

FIGURE 9.—Composition board used as an interior finish.

TWO-FAMILY FARMHOUSES

While it is an old custom for farm families to retire to town, leaving a married son or daughter on the farm, there are also examples of retiring farmers who have found it more satisfactory to stay on the land. This practice helps to reduce the cost of living, the older people's experience and active assistance help to increase the farm income, and their savings are more likely to be used in ways that improve rural life than if they moved to town.

The two families should be provided with separate living quarters, for each will have some interests in which the other does not join. One way is to provide two houses; but a more economical way, where the existing farmhouse is large and in sound condition, is to divide it into two separate apartments. House 18 is an example of how one type of farmhouse can be made into a two-family dwelling.

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[4] Suggestions on interior finishes will be found in Department of Commerce bulletin House Insulation (10 cents); in Modern Home Interiors (10 cents), published by the National Lumber Manufacturers Association, Washington, D. C.; and in catalogs of manufacturers of interior-finish materials and millwork.

EXTERIOR DESIGN

A pleasing exterior of the farm home is not to be assured without careful study of the various elements that form the completed picture. These elements are the walls and roof, which influence the proportions or mass effect (fig. 10), and the windows, dormers, doors, porches, entries, chimneys, exterior trim, and paint, which are means of attaining interesting detail (fig. 11). The relation of height to width should be studied for mass effect. A building kept "close to the ground" seems to grow from the soil and has the appearance of solidity, but a house on too high a foundation gives an impression of restlessness.

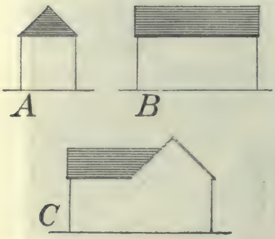


FIGURE 10.—A square outline (*A*) lacks variety, an oblong outline (*B*) obtains variety in greater length than height, and an irregular outline (C) gives still greater interest to the silhouette.

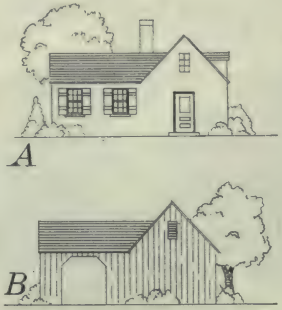


FIGURE 11.—Windows, doors, and chimneys add interest, because they indicate use, in either a house (*A*) or a barn (*B*).

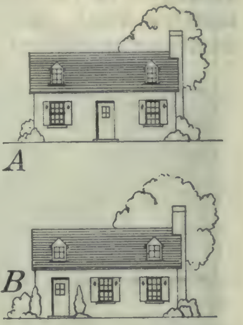


FIGURE 12.—Balance can be achieved with either symmetrical (*A*) or nonsymmetrical (*B*) arrangement of doors and windows.

Doors and windows should be spaced to produce a pleasing arrangement, which may be either symmetrical or nonsymmetrical. Either arrangement can produce an effect of balance (fig. 12), but poor balance is likely to result if windows and doors are merely openings through the walls without regard to location and size (fig. 13).

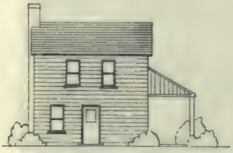


FIGURE 13.—An example of poor balance

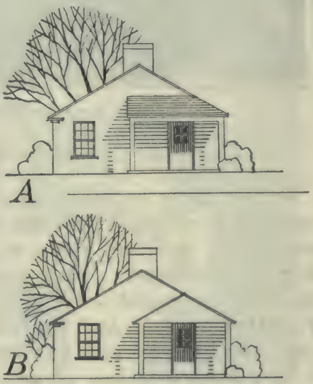


FIGURE 14.—A porch should harmonize with the rest of the house: *A*, Porch with roof lines lacking in harmony: *B*, porch with harmonious roof lines.

From the standpoint of appearance, a porch is often difficult to add to a home satisfactorily. For example, in figure 14, *A* the porch appears to be but an extended strip of the main roof bent across the front. It is obviously a cheaper type of construction than the rest of the house and is therefore out of keeping with it. In figure 14, *B* the porch reflects the construction and roof lines of the house and is therefore more in keeping with the design as a whole; it appears to be more definitely a part of the house than does the other, which looks like a lean-to.

Proposed changes should be studied on paper before construction begins. Only by means of scale drawings can the proportions of the composition be seen and reasonable assurance obtained that the result will be satisfactory.

The exterior of the completed building should reflect the interior arrangement of rooms which is governed by the requirements of living. For economy in construction the plan should be simple and straightforward, with the least possible number of angles and breaks. The location of doors and windows should be studied with regard to the exterior appearance of the completed structure, and to the furnishing of the rooms as well as with regard to convenience, light, and ventilation. In adding space to a house, the style of the old building as well as the new needs should be considered.

The details of an addition should correspond to those of the original structure. Whatever the style of the old house, simplicity should be the watchword in making improvements. Glaring examples of overdecoration are the elaborate and fantastic designs of many houses built at the turn of the last century. But the colonial and New England farmhouses built in the latter half of the eighteenth century and the early part of the nineteenth century, when economy was necessary, still stand as models worth imitating. These homes are adequate proof that simplicity of design is more enduring than elaborate ornamentation.

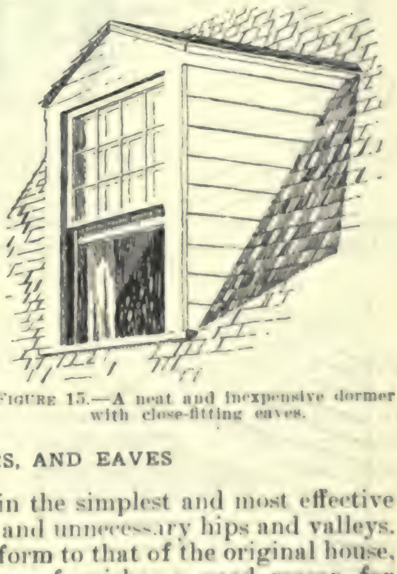


FIGURE 15.—A neat and inexpensive dormer with close-fitting eaves.

ROOFS, DORMERS, AND EAVES

The roof should cover the house in the simplest and most effective way, avoiding complicated framing and unnecessary hips and valleys. The pitch of an addition should conform to that of the original house, unless the use of the new attic space furnishes a good reason for change.

Dormers admit light and air to the space under the roof, and often are needed to permit use of that space for living. When properly used they add to the appearance of the house.

Dormers should be kept as small and compact as lighting and ventilation will permit. Figure 15 illustrates a type that is simple in construction, unpretentious, and practical. To obtain narrow casings, spring balances or spring bolts should be used instead of sash weights. A pair of casement windows instead of the double-hung sash would give twice the opening for ventilation. Casement windows in dormers are most satisfactory on the sheltered side of the house. They should swing in, and must be carefully designed and constructed if they are to keep out driving rains. Weather strips aid in making them tight. Construction details for a dormer are shown in figure 16.

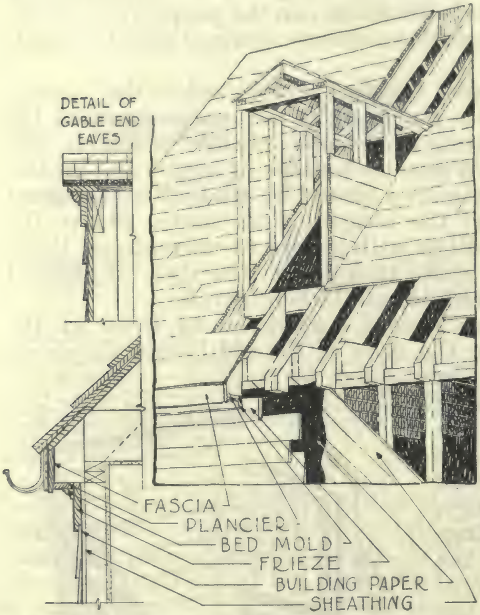


FIGURE 16.—Construction details for dormer and for eaves.

The appearance of the house is often improved by neat, close-fitting eaves, especially at gable ends. They give a simple effect, are economical, and help to keep the house from being damaged by windstorms. Figures 16 and 17 illustrate their use and construction. The appearance of an old house often may be brought up to date by trimming wide eaves to modern lines and removing "gingerbread" decorations.

WINDOWS AND SHUTTERS

The interior arrangement of a house may be entirely satisfactory, and yet on the exterior the wall openings may appear awkward. This fault cannot always be entirely avoided in remodeling an old house.

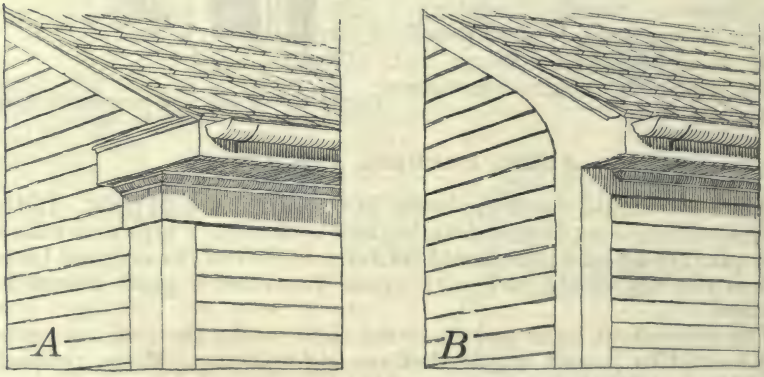


FIGURE 17.—Box cornice at gable ends: *A*, Cornice built with return against gable; *B*, cornice cut flush with the end of the building.

Low window sills are less desirable than high sills, especially on upper floors. The former give a sense of insecurity in the room and add to the difficulty of placing furniture. A height of 32 inches is fairly safe against children falling out and permits placing a bed or table in front of the window.

Shutters are a question of personal taste. As a matter of utility they offer shade and ventilation in hot weather, and protect first-floor rooms against intrusion at night when windows must be left open or when it is necessary to leave the house unoccupied. On the other hand, if the shutters are to be closed, outside screens of full height can be used only with special window frames.

The ornamental value of shutters is illustrated in the suggested remodeling for house 4 (fig. 28). With the long, low house shown, the windows without shutters would appear somewhat lost. The shutters give an effect of greater width to the window openings, which harmonizes with the length of the building. Since the window openings are dark, the shutters should be painted dark; green is the usual color.

Shutters need not be of the customary venetian type, but can be designed to harmonize with the style of building. Simple panels with a fret-saw opening or vertical boards held together with horizontal battens are inexpensive and can be made in the home workshop. Two simple types are shown in figure 18. All shutters should be provided with metal catches to prevent them from swinging in the wind.

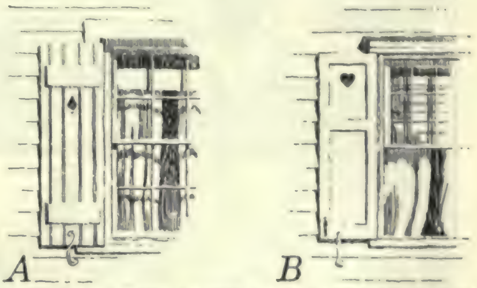


FIGURE 18.—Simple types of shutters: *A*, Vertical boards held together by horizontal battens; *B*, simple panels with fret-saw opening.

PORCHES AND HOODS

Porches should harmonize with the style of the building of which they are a part. The porch floor, as a general rule, should be an easy step below the first-floor level. Figure 19 shows simple types of front porches and a sun porch with a deck, and figure 20 an enclosed rear porch. All except completely enclosed porches should have sufficient slope to the floor to shed water easily, usually 1 inch to 6 feet being sufficient.

In mild climates a back or side porch fitted with screens and glass frames makes an all-year work area for laundry work, churning, the preparation of vegetables for canning, and other household tasks. A washbasin or sink with running water adds to its usefulness. If electric current is available, two or more convenience outlets are generally desirable. Summer meals are usually more enjoyable on a screened porch than indoors.

It is not always possible or desirable to place a porch over every exterior doorway. In such cases, a hood over the door offers weather protection and provides a decorative motive. (See figs. 33, 46, and others.)

COLOR

With the structural work of remodeling completed, there remains the problem of blending new and old construction together by the use of paint or stain. The latter is the cheaper and more durable type of finish for exterior wood. Dark paints are cheaper and more durable than light ones, and white is the least durable and most expensive. However, nothing takes the place of white paint for the exterior finish of the early American style of farmhouse, especially where trees form a dark background throughout the year. With other styles of farmhouses, and where there is much snow and few trees, warmer colors are often used. Ivory, cream, and soft shades of yellow, brown, or gray are used with good effect.

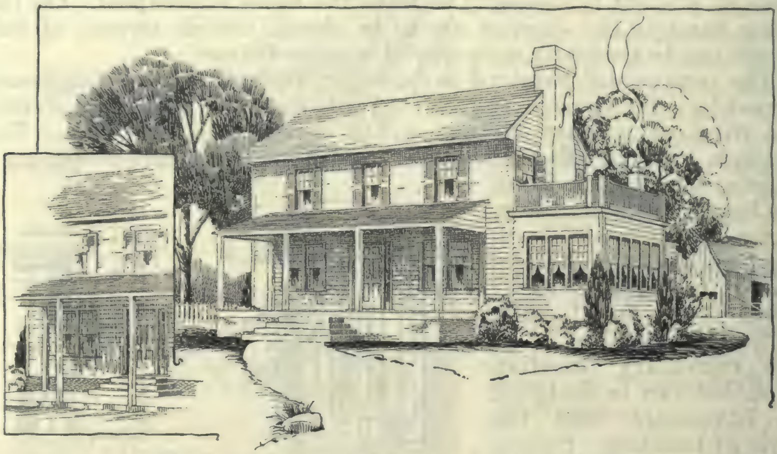


FIGURE 19.—Attractive front and sun porches.

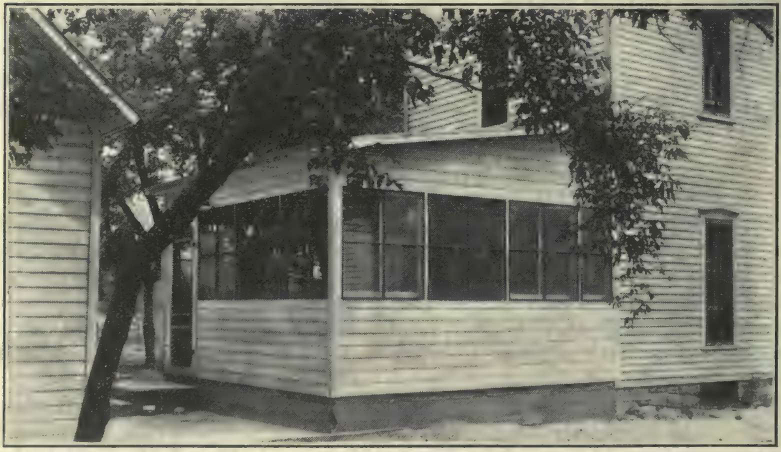


FIGURE 20.—A screened and glassed-in work and dining porch.

YARD IMPROVEMENT

Well-placed walks and fences add to the appearance of the farmstead and protect the house, lawn, and shrubbery (fig. 21). Walks are worth many times their cost in reducing the amount of dirt tracked into the house, especially in bad weather. Concrete, brick, or gravel, or sometimes the picturesque stepping stones, can be used.

The appearance of the home is also improved by plantings around it. As a general rule a few trees to provide shade, some flowering shrubs of native growth grouped close to the building to break harsh lines, and a bed or two of flowers selected for their color value will be sufficient decorative relief.

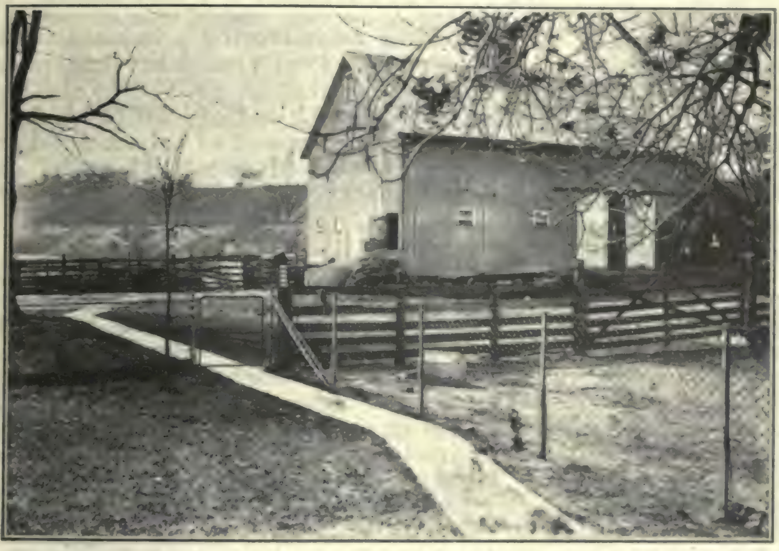


FIGURE 21.—A walk reduces the amount of dirt tracked into the house, and good fences keep poultry out of the dooryard.

PLANNING THE IMPROVEMENTS

PUTTING THE PLAN ON PAPER

The old house should be accurately measured, and the walls, partitions, doors, windows, stairs, chimneys, and other parts drawn to scale on a plan. Good-quality paper should be used and the lines should be firm and clear, preferably in ink. A good scale is one-fourth inch to the foot of actual size.

Contemplated changes in arrangement should not be made on the plan of the old house. It is better to lay tracing paper or heavy tissue over that plan and work out the new arrangement on the transparent paper. Pieces of cardboard may be cut to scale to represent the furniture and moved around on the plan as an aid in deciding on the best arrangement of partitions, doors, windows, and equipment. Proposed changes can be drawn quickly on the transparent paper and thus be readily compared.

In planning, time should be taken to think out exactly what is wanted, the best way of doing the work, the best materials to employ, and the effect produced by using different materials in various ways. The first plan usually can be improved by further study. A second, third, or fourth alternative is very likely to produce a more desirable result and yet require less change. Since it takes almost as much labor to patch a partition and clear away the debris as to build a new one, no more tearing out than is actually necessary should be considered. For best results, the plan should be checked and put in final shape by an architect or an engineer who has been trained in planning farmhouses.

SELECTION OF MATERIALS[5]

Choice of materials for building or improving a house depends largely on the owner's preference, on local availability and price, and on the skill of local builders in using one material or another. The use of lumber from the farm wood lot and of local stone, sand, and gravel, or adobe, all help to reduce the cost of a farm building. The quantities needed should be estimated and the material got ready and hauled at slack times before building is started. Lumber should be cut as nearly as possible to the sizes that will be needed, and stacked under cover to season.

New kinds of materials should be investigated, as improvements are being made in all lines. A new development in low-cost, fire-resistant construction is the use of cinder concrete blocks for walls and precast concrete joists and slabs for floors. For low cost the walls are painted with cement paint, and such walls appear to give good service in moderate climates. Stucco would be a more durable though more expensive outside finish. Lath and plaster or other interior finish on furring strips to form an air space would add to the warmth of the wall. There are many new developments in inside finishes. Among these are new kinds of plasters and new bases on which to apply finishes. The use of composition board, plywood, and insulating materials has been discussed in a preceding section (p. 11) The use of nonabsorbent wainscotings, which are available in a variety of color patterns, should be considered for the bathrooms and kitchens of the better grade of houses.

Building materials usually can be purchased on more favorable terms if the order for the entire bill of goods is placed at one time, after prices have been obtained from two or more reliable dealers and if arrangements are made for prompt payment. Because there is an advantage in quantity purchasing, neighbors may find it worth while to consolidate their orders.

COSTS

Unit costs of foundations, walls, floors, and other major items have been listed below to aid persons in forming a general idea of the cost of work that they contemplate. These costs are for ordinary construction, all materials being purchased at dealers' prices and all labor hired at rates common in farm communities. The range in costs is intended to cover variations in different parts of the country. Where native materials may be obtained at low prices or when much of the work is done by the owner or his family, costs may be much less than those shown.

---

[5] Several of the associations of manufacturers of building materials have good publications on the use of their products.

UNIT COSTS OF BUILDING OR REMODELING

Item	*Range of cost*
Excavating—usually done by owner.	
Foundations, per linear foot of wall or sill:	
Masonry wall 3 feet high, with sill	$1.25 to $2.25
Masonry wall 5 feet high, with sill	1.75 to 3.25
Masonry wall 7 feet high, with sill	2.25 to 4.25
Masonry piers 2 feet high, sills 6 by 8 inches	.35 to .55
Masonry piers 4 feet high, sills 6 by 8 inches	.45 to .75
Interior floor support, post and girder; per linear foot of girder	.25 to .40
Cellar floor, 4-inch concrete, per square foot	.12 to .20
Drain for foundation: 4-inch tile, laid, per linear foot	.10 to .15
Waterproofing floor and wall, per square foot	.10 to .15
Exterior walls, per square foot of plain wall surface. For gable ends, add to cost of plain wall per square foot	.10 to .15
Vertical board and batten or horizontal siding with framing; outside painted, interior not finished	.12 to .18
Vertical board and batten or horizontal siding with framing; outside painted, interior sheathed and papered on cheesecloth	.20 to .30
Siding, studs 16 inches on centers; outside painted, interior wainscot and wallboard	.20 to .30
Siding on sheathing, studs 16 inches on centers; outside painted, interior plastered and papered	.30 to .40
Brick 8 inches thick, brick veneer, or brick backed with 4-inch tile, inside plastered and decorated	.40 to .60
Cinder or concrete block, 8 inches thick finished both sides with cement paint	.20 to .30
Cinder or concrete block or hollow tile; outside stuccoed, inside plastered	.30 to .50
For furring and board insulation as plaster base for masonry walls add to above figures per square foot	.08 to .15
Ceilings, per square foot:	
Sheathed, papered on cheesecloth; joists 2 by 6 inches, 2 feet on centers	.10 to .15
Lath and plaster, papered; joists 2 by 6 inches, 16 inches on centers	.12 to .20
Lath and plaster, papered; (under second-floor joists)	.08 to .15
Insulating board or wallboard, not painted; joists 2 by 6 inches, 16 inches on centers	.08 to .15
Fill insulation over ceilings 2-inch fill	.05 to .08
4-inch fill	.10 to .16
Partitions, per square foot:	
Vertical board, battens both sides, stained; without studs	.08 to .12
Sheathed, both sides papered on cheesecloth; studs 2 by 4 inches, 2 feet on centers	.20 to .30
Lath and plaster, both sides papered; studs 2 by 4 inches, 16 inches on centers	.25 to .35
Wainscot, stained, with wallboard or insulating board above not finished; studs 2 by 4 inches, 16 inches on centers	.15 to .25
Floors, per square foot:	
Softwood; joists 2 by 10 inches, 16 inches on centers, with bridging	.15 to .25
Softwood; joists 2 by 10 inches, 16 inches on centers, with subfloor and bridging	.20 to .35
Hardwood; joists 2 by 10 inches, 16 inches on centers, with subfloor and bridging	.25 to .50
Concrete, 4 inches thick, on fill, troweled surface	.12 to .20
Concrete; precast joists 3 by 8 inches, 2-inch floor slab	.20 to .30

UNIT COSTS OF BUILDING OR REMODELING—continued.

Item	*Range of cost*
Roofs, per square foot:	
Wood shingle, on slats; rafters 2 by 6 inches, 16 inches on centers	$0.15 to $0.22
Asphalt shingle, on sheathing; rafters 2 by 6 inches, 16 inches on centers	.15 to .22
Roll roofing, 2 inches lap, on sheathing, rafters 2 by 6 inches, 16 inches on centers	.12 to .17
Asbestos shingle, hexagonal or Dutch pattern; rafters 2 by 8 inches, 16 inches on centers	.22 to .30
Slate or asbestos shingle, American patterns, on sheathing; rafters 2 by 8 inches, 16 inches on centers	.25 to .40
Steel, galvanized V-crimp, on sheathing; rafters 2 by 6 inches, 16 inches on centers	.15 to .22
Tin, on sheathing; rafters 2 by 6 inches, 16 inches on centers	.20 to .30
Built-up covering, on sheathing; rafters 2 by 8 inches, 16 inches on centers	.15 to .30
Hips and valleys, galvanized-iron flashing, per linear foot of hip or valley	.40 to .80
Same, with copper, zinc, or lead flashing	.75 to 1.25
Same, flashed with roll roofing	.25 to .50
Roof cornice, with gutters and downspout	.40 to .80
Porch cornice and girder with gutter and downspout	.75 to 1.25
Windows, average size; with frames and trim complete in place, each	8.00 to 16.00
Windows, cellar or attic	3.00 to 5.00
Window screens, average size, each	1.50 to 3.00
Doors, inside, average size; with frames and trim, complete in place, each	8.00 to 12.00
Doors, outside, average size; with frames and trim, complete in place, each	12.00 to 25.00
Screen doors, average size, each	2.00 to 6.00
Stairs, finished, per tread	2.50 to 5.00
Stairs, cellar, per tread	.50 to 1.00
Kitchen cupboards length of 8 foot, room height, with doors and drawers; complete in place, each	50.00 to 75.00
Kitchen cupboards, open shelf, each	18.00 to 25.00
Chimneys; with flue linings, per foot of height	2.25 to 3.00
Extra flue, per foot of height	.75 to 1.00
Fireplace only, not including base or chimney	30.00 to 75.00
Fireplace base, southern conditions, no cellar	5.00 to 15.00
Fireplace base in cellar	20.00 to 35.00

To use the foregoing tabulation, first find the total amount required of each listed item, then multiply each amount by the corresponding unit cost, and finally add the products. For example:

An addition 20 feet square with piers and sills under three outside walls and one line of piers and sill through the center would have $4 \times 20 = 80$ linear feet of foundation. This length of foundation having piers 2 feet high and sills 6 by 8 inches should cost between $\$0.35 \times 80 = \$28$ and $\$0.55 \times 80 = \$44$, if all material and labor are bought. The lower figure would be used where materials and labor are relatively cheap, and the higher figures where materials and labor are relatively expensive. Miscellaneous expenses will add perhaps 10 percent to the total of the listed items.

Unit costs of building vary considerably in different sections, according to local costs and quality of materials and to wages and efficiency of labor. In general, costs are lower in the central South than in other sections. Costs are usually relatively low near the sources of material and in the open country, and higher where the material must be shipped long distances and near large cities. For these reasons persons contemplating building are advised to obtain estimates from reliable local builders, and to use the unit cost data only for preliminary computations.

Cash costs of farm construction are usually less than estimates based on the foregoing tabulations show, because it is common for the farm owner to do part of the work himself and to make some use of material that is furnished by the farm or is cheaply obtainable in the neighborhood. When this is done the cost will be correspondingly reduced, as may be noted in the reports of estimated and actual expenditures for the houses discussed in this bulletin.

Another method of making an approximate estimate, if the cost of the material required is known, is to add 60 to 100 percent of the materials cost for labor, the percentage depending on local conditions and the type of work and quality of finish required.

FINANCING

Small improvements usually can be made by members of the family without special financing. Many farmers have put in water systems and made other major improvements a step at a time, paying as they went. Payment out of income or savings is recommended whenever possible. Where this cannot be done, a loan as a starter to get the work under way, or to obtain the benefit of a cash price on materials, may be worth many times its cost.

If a farm owner who wishes to make home improvements does not have the necessary money on hand and cannot make satisfactory arrangements with private lenders, three sources of Government assistance are open to him. The terms and conditions for loans given in the following paragraphs are those prevailing in June 1935.

(1) Production credit association loans. Production credit associations make loans to members for improvement of farm homes. Such loans are ordinarily made for 12 months but may be made for 18 months when conditions justify such terms provided a partial payment of 50 percent is made within 1 year. Loans may be renewed from time to time provided repayments and security justify such action, but the total period of the loan and renewals may not exceed 3 years. The amount of the loan depends on the borrower's ability to repay, but cannot exceed $2,000 on a single dwelling, nor be less than $100. The note must be secured. Interest is charged at 6 percent per annum on the unpaid balance and there are other small charges. Further information may be obtained from the nearest production credit association.

(2) Loans insured by the Federal Housing Administration. The Federal Housing Administration does not make loans, but has arranged with banks and other agencies to make insured loans for home and farm improvements. No security, comakers, or endorsers are required. The loan may be from $100 to $2,000, but is limited so that the yearly payments on it will not exceed one-fifth of the borrower's average annual income. The loan may run for not more than 5 years, and payments can be made when crops are sold. The maximum cost of interest and fees must not exceed a rate equivalent to $5 paid in advance on a $100 1-year loan, to be repaid in monthly

installments. Information may be obtained from local banks and building-material dealers or from county agents.

(3) Federal land bank and Land Bank Commissioners loans. Loans from a Federal land bank are secured by first mortgages on the farm, but Commissioner's loans may be secured by second mortgages. Both of these loans may be amortized over a long period of years. New loans are being made by the Federal land banks at 4¼ percent interest. (This rate is in effect only on loans made through national farm-loan associations; the rate is 4¾ percent on direct loans.) A temporary reduction below these rates will be in effect on all interest payments prior to July 1, 1938. Commissioner's loans bear interest at 5 percent. Additional information may be obtained from the Federal land bank of your district or from a local national farm-loan association, or from the county agent.

METHODS OF DOING THE WORK

Common methods of remodeling farmhouses are: (1) The owner and his family do the work themselves; (2) one or more skilled men are hired; or (3) a contract is let for the entire job, including labor and material. The first method involves the least cash expenditure, but the work is likely to lack the good finish that skilled workmen produce and to require considerable time, prolonging the inconvenience to the family. The second method is very common farm practice, and usually gives satisfactory results. The owner hauls materials, excavates for the cellar or foundation, and helps with other work, thus reducing the expense. (See p. 42.)

Letting a contract for the work has the advantages of quick completion, and of making it possible to know in advance what the cost will be. Securing the services of an experienced contractor will save the owner much time and trouble. After the owners have studied their problems carefully and settled on their plans, bids should be obtained from at least two reliable men. The Federal Housing Administration makes the following recommendations:

> **You should not pay for the work or sign a note covering the cost of the work without receiving a written guarantee.**
>
> **The following form is customary and you are advised to require it substantially as given below:**
>
> **(Guarantee)**
>
> **To ______________________________ Date ____________________. The undersigned hereby certifies that the work which the undersigned contracted to perform for you on the premises located at ___________ _____________ _________**
> **(Address) (Town)**
> **_________ ______________ ______________ for a total sum of $______ has**
> **(County) (State)**
> **been completed in a workmanlike manner. The undersigned further guarantees said work against defects in materials and workmanship for a period of 1 year.**
> **Signed ______________________________**
> **(Contractor)**

Contract work should have special advantages in communities where many home improvements are to be made. If neighbors can arrange their building schedules to keep a contractor busy for the entire season, he should be able to make better prices than if his work is scattered and intermittent. This should also justify more use of labor-saving equipment such as concrete mixers, power saws, floor sanders, and portable scaffolding.

EXAMPLES OF REMODELING FARMHOUSES

From records of remodeling obtained by the Farm Housing Survey, 13 jobs dealing with representative types of houses and illustrating good methods of making improvements have been selected for discussion in the following pages. Alternate plans also are presented for most of these houses.[6] Five examples of remodeling suggested by State agricultural colleges are also included, based on real farm situations not covered by the reports of actual construction.

The cash expenditures for remodeling these houses are in every case less than those estimated by using the unit costs given on pages 21 and 22. This is partly because the work was done when prices were lower than those given, but largely because the owners furnished material and labor that did not involve cash outlay, which is typical of farm building. Differences between the estimated costs of the owners' remodeling and those of the alternate plans are due largely to inclusion in the alternate plans of more storage spaces and more modern conveniences than were provided by the owners.

In many of the plans shown in the following pages, certain space uses and locations of kitchen and other household equipment are indicated by numbers assigned according to the following list:

1. Closet.
2. Coats and wraps.
3. Pots.
4. Wood box.
5. Stove.
6. Refrigerator.
7. Work table.
8. Sink.
9. Dish cabinet.
10. Circulator heater.
11. Linen closet.
12. Cupboard.
13. Pass cupboard.
14. Wheel table.
15. Pantry.
16. Brooms.
17. Draft cooler.
18. Sewing closet.
19. Washing machine.
20. Storage.
21. Folding table.

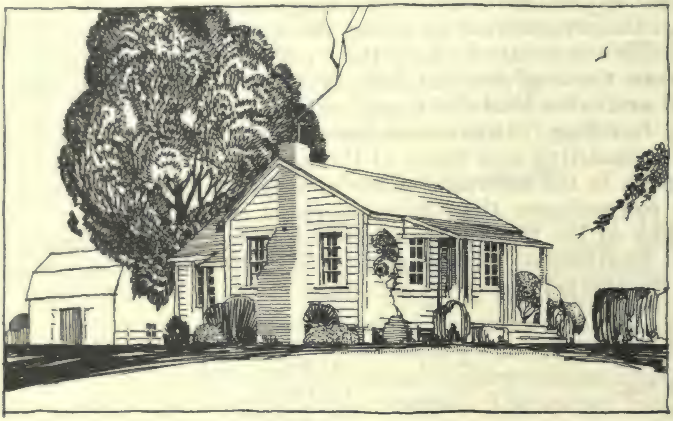
---

[6] Most of the kitchen arrangements shown in the alternate plans were contributed by Louise Stanley, Chief of the Bureau of Home Economics, who also aided by helpful criticism in planning other features of the houses.

HOUSE 1 (SOUTH CAROLINA)

Before remodeling, 1 room; added 2 bedrooms and porch; cash expenditure $335; estimated full-purchase [7] cost of work done $725, of alternate plan $800.

Even so simple a problem as adding 2 bedrooms to a small 1-room farmhouse calls for careful planning if the best arrangement is to be obtained. Figure 22 shows how 2 bedrooms were added to house 1. The cost was low, and the result has been satisfactory to the owner. However, putting the fireplace and the front door in the left-hand bedroom makes this the living room, and makes it necessary to pass through the right-hand bedroom in going from the living room to the kitchen. Thus neither room has privacy.



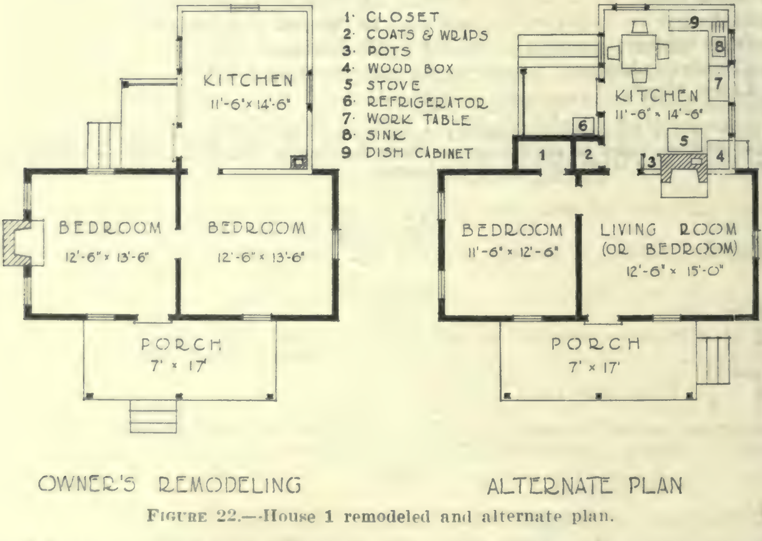


FIGURE 22.—House 1 remodeled and alternate plan.

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[7] The estimated full-purchase cost is the estimate of cost based on unit costs as given on pp. 21 to 22, selected within the stated price ranges according to the section in which the house is located.

The alternate plan gives privacy to the left-hand bedroom. It adds two closets, but makes no other increase in either the floor area or the cost of the building. The location of the fireplace is an important factor in this solution. Besides serving the kitchen range with a flue, the fireplace definitely establishes the living room. The latter, being more important as the home center, should be larger than the adjoining bedroom. A wood box, filled from the outside, would serve both stove and fireplace; no other heating is required. The slightly greater cost of the alternate plan provides the two closets, the sink, an extra door, and relocation of one window.

This house also suggests a method of adding one room to a two-room house. If additional rooms are needed later, they might be handled as is shown for house 4.

HOUSE 2 (TEXAS)

Before remodeling, 3 rooms; proposed to add 1 bedroom, bath, and screened porch; estimated full-purchase cost, $600 to $900.

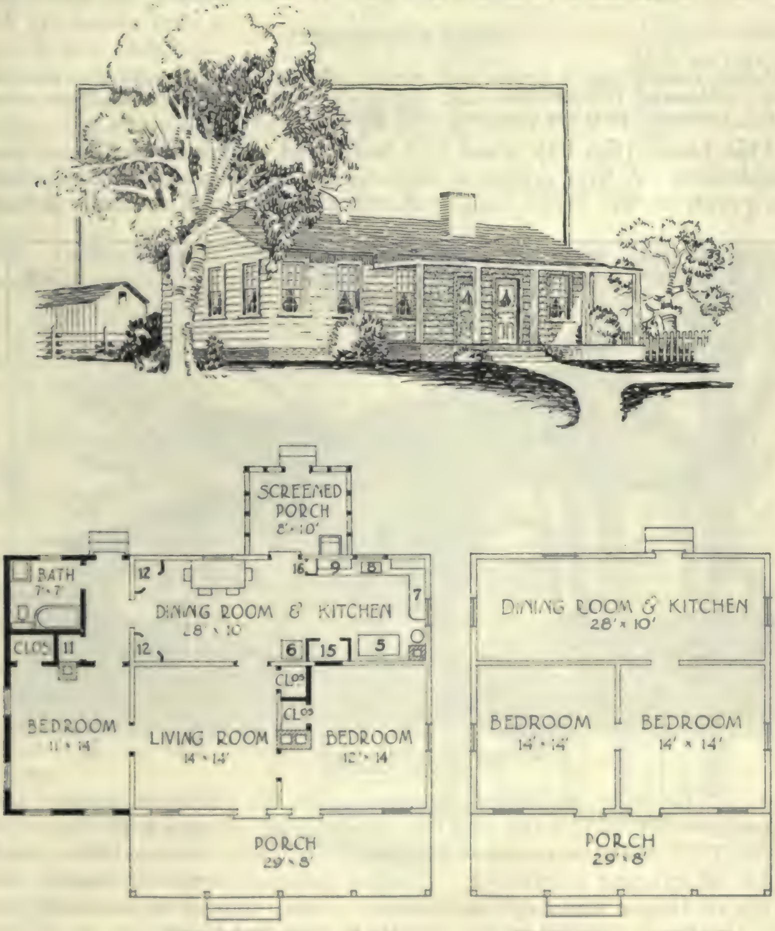


FIGURE 23.—House 2 and plan for remodeling.

The original house, illustrated in figure 23, is a type common in parts of the South. The plan for remodeling was prepared by the Agricultural and Mechanical College of Texas. The changes would convert a three-room shelter into a comfortable, convenient home, with better light and ventilation than the original house.

The closets, pantry, cupboards, sink, and kitchen cabinets promote order and save effort in the house. Chimneys are provided for stoves in the living room and in both bedrooms. If preferred, a circulator heater burning wood or oil and located in the living room should heat the whole house.

The same remodeling plan might be used for a house with three rooms in a row, like the front part of this house. In that case a shed-roofed addition would be added at the rear for the kitchen and bathroom. One or two additional bedrooms could be added at the bathroom end and corner of this house and made accessible by turning the two closets there into a hallway. (Plan 6525 in Farmers' Bulletin 1738 illustrates such an addition.)

HOUSE 3 (NEBRASKA)

Before remodeling, 4 rooms and porch; added 3 rooms; cash expenditure, $450; estimated full-purchase cost for work done, $900; for alternate plan, $1,425, including $250 for plumbing and heating.

This house (fig. 24) when first built had only a living room and a bedroom. A first addition comprised a kitchen and two porches, the porch on the front being subsequently enclosed to make a bedroom. The second addition, consisting of the living room and two bedrooms (fig. 25), is the one for which costs are given above.

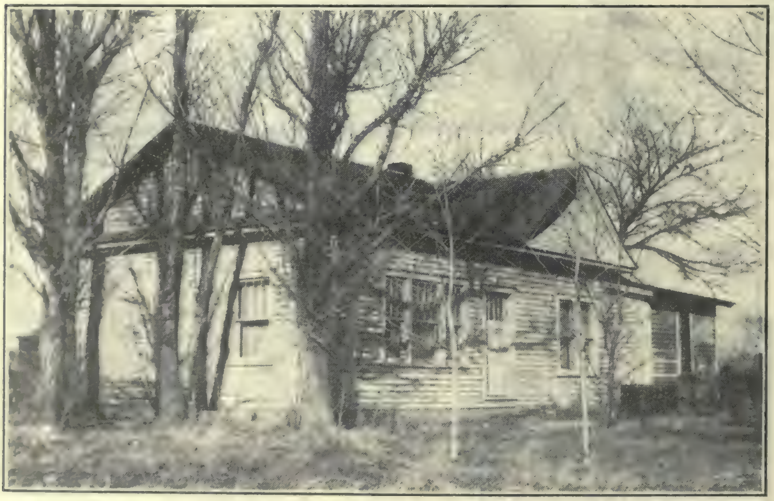


FIGURE 24.—House 3 in 1934.

The 1933 addition measured 16 by 28 feet, and included the installation of gas and electricity. Further improvements desired by the owner include a water system and bathroom. The changes made provide the space needed in the simplest way, but there are no closets and the arrangement of the rooms has some disadvantages. The kitchen serves as a hall to all of the rooms, and each of the three rear bedrooms must be entered from the dining or the living room

The alternate plan converts the center rear bedroom into a bathroom and a small hall to give greater privacy to the bedrooms. The front bedroom and kitchen are made into a combined kitchen-dining room, and moving the chimney takes the stove out of the line of traffic. The original dining room is enlarged and used as the living room, and the other part of the present living room becomes a bedroom or library and closets. Cross ventilation for the bedroom on the right is obtained through high windows onto the screened porch. The living room in the center of the house is convenient to all the other rooms, but is no longer the only path from the kitchen to the bedrooms.

A corner of the enlarged living room, with a ceiling beam carrying the load of the

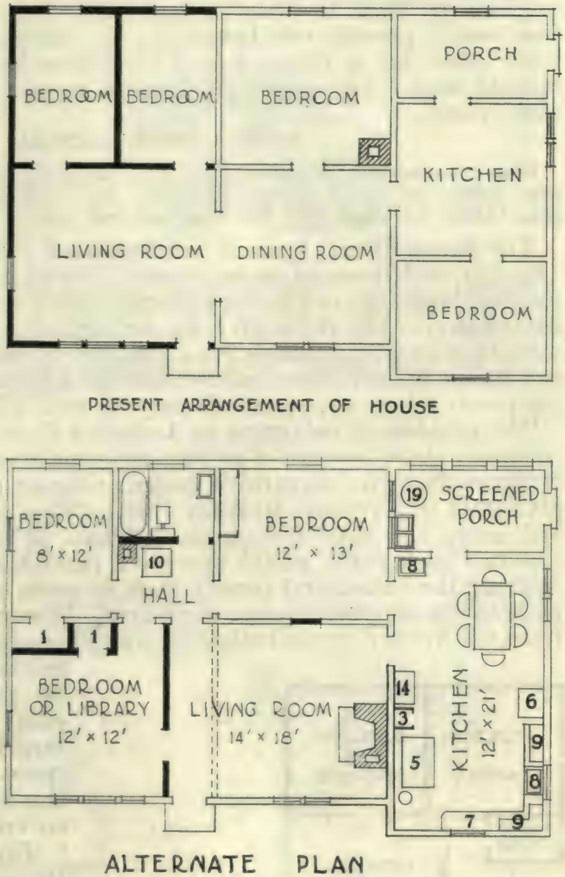


FIGURE 25.—Present arrangement of house 3 and alternate plan.

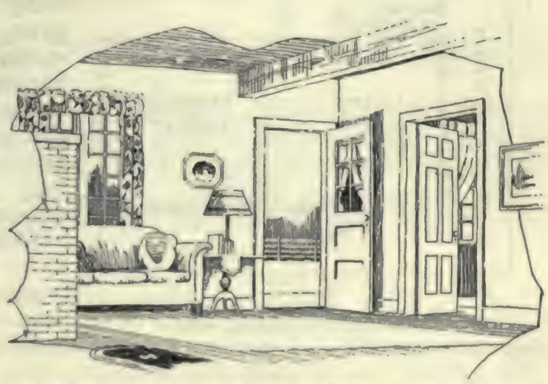


FIGURE 26.—The living room in house 3, alternate plan, viewed from the kitchen door.

original partition, is shown in figure 26. The new part of the house thus would provide two bedrooms, the bathroom, and a small hall, with space for a chimney and circulator heater. In a moderate climate such a heater and the kitchen range should keep the house comfortable.

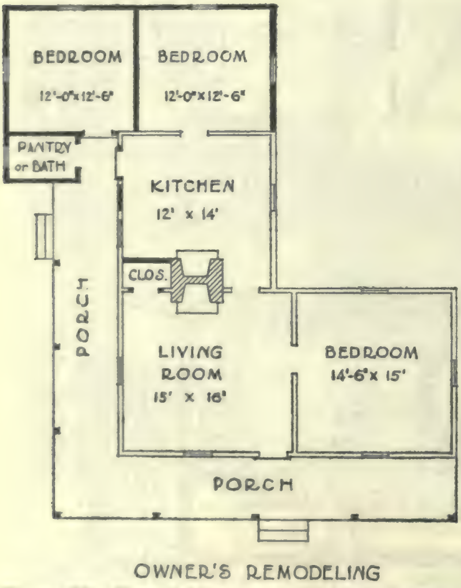
HOUSE 4 (SOUTH CAROLINA)

Before remodeling, 3 rooms; added 2 bedrooms and porch; cash expenditure, $400; estimated full-purchase cost for work done $825; for alternate plan $1,325, including $200 for plumbing and heating.

The owner of this house is much pleased with the improved home (fig. 27), and it would be satisfactory for many households. One of the new bedrooms can easily be heated from the kitchen. Some families, however, would prefer an arrangement whereby the kitchen would not be used so much for a passageway between the living room and the back bedrooms; and to have one bedroom opening only onto the porch might not be satisfactory in cold weather.

The problem of enlarging an L-shaped three-room house is rather common. Another way of adding the same amount of space is shown in figure 28. (A comparable design is shown as the alternate house plan 6513 in Farmers' Bulletin 1738.) This arrangement is simple and keeps the open feeling so desirable in southern homes. The screened back porch would provide a place for men to wash before entering the house, and permit them to go to any part of the house without crossing the kitchen work area. It would provide also a way from the kitchen to the bathroom without passing through the front bedroom This porch could be protected by glass in cold weather, or made larger and used as a dining space. The open terrace at the left could be made a covered porch if preferred.

The difference between the estimated full-purchase costs of the owner's remodeling and of the alternate plan includes closets, screened porch, bathroom, plumbing, and a heater in the new hall. This solves the problem of heating the bedrooms and bath. Cutting off one-half of the original kitchen chimney is optional. It is suggested because many chimneys in old homes are in a bad state of repair and need rebuilding to eliminate danger of fire.



OWNER'S REMODELING

FIGURE 27.—Plan of house 4 as remodeled by owner.

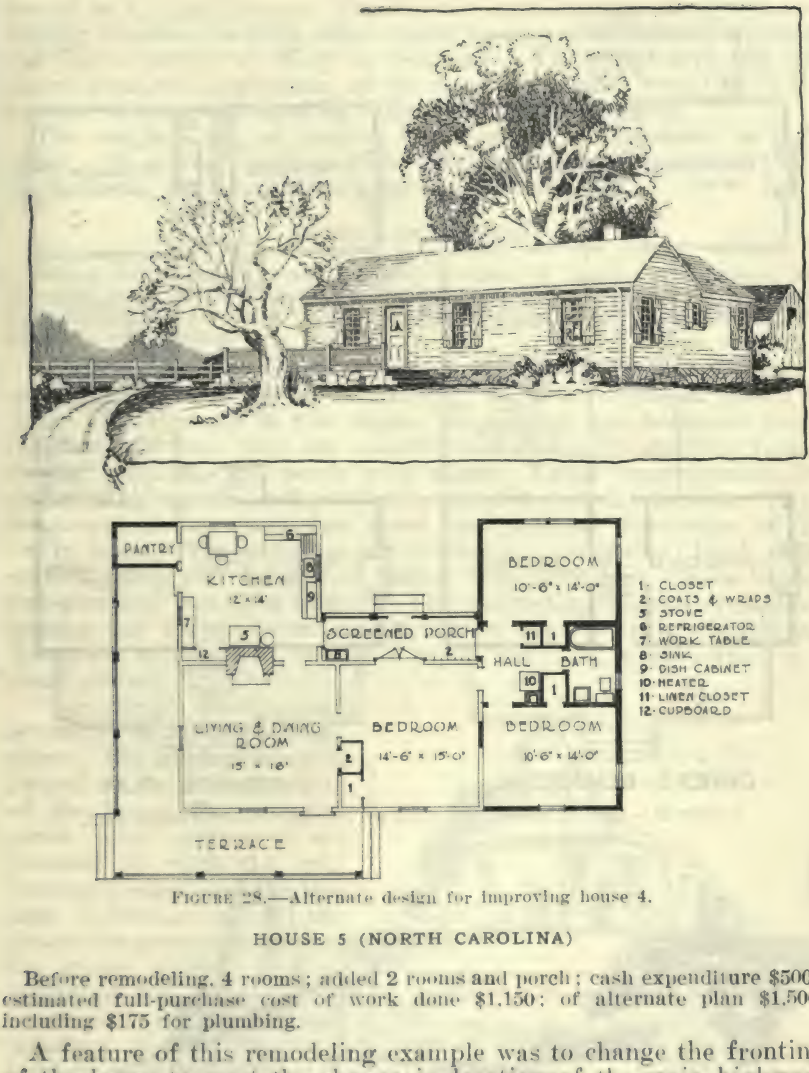


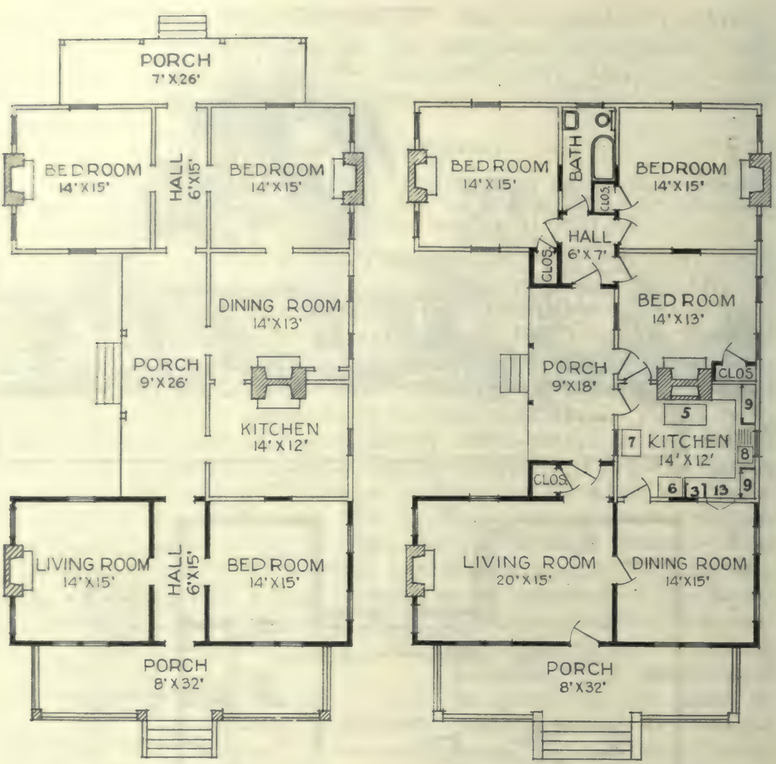
FIGURE 28.—Alternate design for improving house 4.

HOUSE 5 (NORTH CAROLINA)

Before remodeling, 4 rooms; added 2 rooms and porch; cash expenditure $500; estimated full-purchase cost of work done $1,150; of alternate plan $1,500, including $175 for plumbing.

A feature of this remodeling example was to change the fronting of the house to meet the change in location of the main highway, which originally passed south of the house but when rebuilt and straightened passed on the north. The house owner added a new living room, bedroom, and porch at the north end of his home (fig. 29) to face the highway, retaining the same open effect as the original.

An alternate plan (fig. 29) suggests a larger living room by omitting the hall, and shows how closet space and a bath could be added by closing what is now the rear door and doing away with the porch there. In warm climates, this plan should make a very satisfactory farm home, with the side porch serving as a hallway; in cold climates the probable use of the center bedroom as a hall



OWNER'S REMODELING

ALTERNATE PLAN

FIGURE 29.—Plan of house 5 as remodeled by owner, and alternate plan.

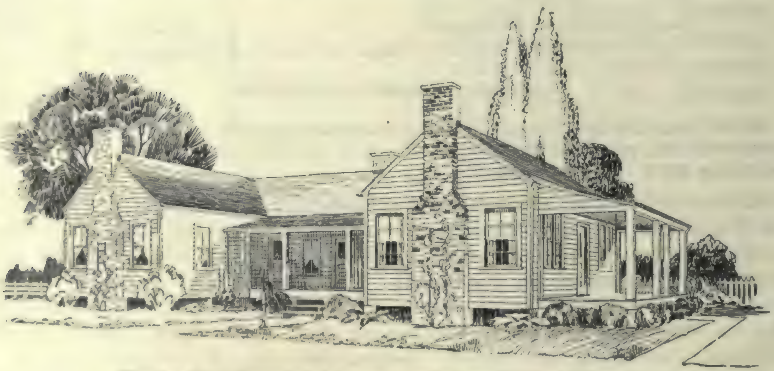


FIGURE 30.—Remodeled house 5 with modernized exterior.

would be a disadvantage. The kitchen opening onto the porch and having windows on both sides should be very comfortable, although the view is partly cut off by the bedrooms. The perspective (fig. 30) shows what the appearance of the remodeled house would be if the exterior were modernized by taking off the heavy eaves.

The simplest way of heating this house is by fireplaces, as indicated. If central heating were desired, a hot-water system with the heater in the living room would be most suitable.

HOUSE 6 (MINNESOTA)

Before remodeling, 4 rooms; added kitchen, 2 bedrooms, sunroom, and screened porch; cash expenditure, $765; estimated full-purchase cost for work done $2,100; for alternate plan with part basement $2,750, including $475 for plumbing and heating.

A typical square brick house of the North Central States is shown in figure 31 before remodeling. The development shown in figure 32 was made in two stages, the kitchen and basement being the first. A year later the owner's and children's sleeping rooms closets, sunroom, and porch were added. Other improvements included a bathroom (without fixtures), hall, archway between living room and dining room, oak floors, and interior decoration of the entire house. The additions are of frame construction; brick walls with furring and insulation would have increased the estimated full-purchase cost $250 to $300. For completing the modernization, heating and water systems and bathroom fixtures are contemplated. Adequate heating will require a piped-warm-air, a hot-water, or a steam system.

This owner's development is worthy of favorable comment. The kitchen wing is located on the driveway side of the house, the screened porch and sunroom are planned to catch the prevailing breezes, and the two new bedrooms utilize the closets for protection against the winter winds. The location of the stairs to the basement is not entirely satisfactory, because they can be reached only by going through the kitchen and dining room.

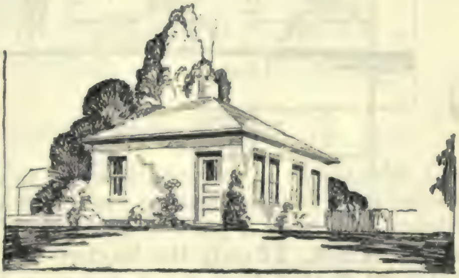


FIGURE 31.—House 6 before remodeling.

An alternate design for remodeling such a house is shown in figure 33. The kitchen would include an enclosed entry at grade level, a real advantage in regions subject to severe winters. A cellar, if needed only for the heating plant, could be excavated under the new kitchen and only a part of the living room, without disturbing the outside walls. If only the kitchen and entry were added, the house could be heated well by a one-pipe (pipeless) furnace under the middle of the living room, but with the new bedrooms and sun porch also, a piped heating system would give better results. If no cellar were needed, or if ground water interfered with use of a cellar, the rear entry could be enlarged to house the boiler and fuel for a hot-water heating plant. The cost would be a little more than for the cellar and warm-air plant. The simple hood over the front door adds to the appearance of this design.

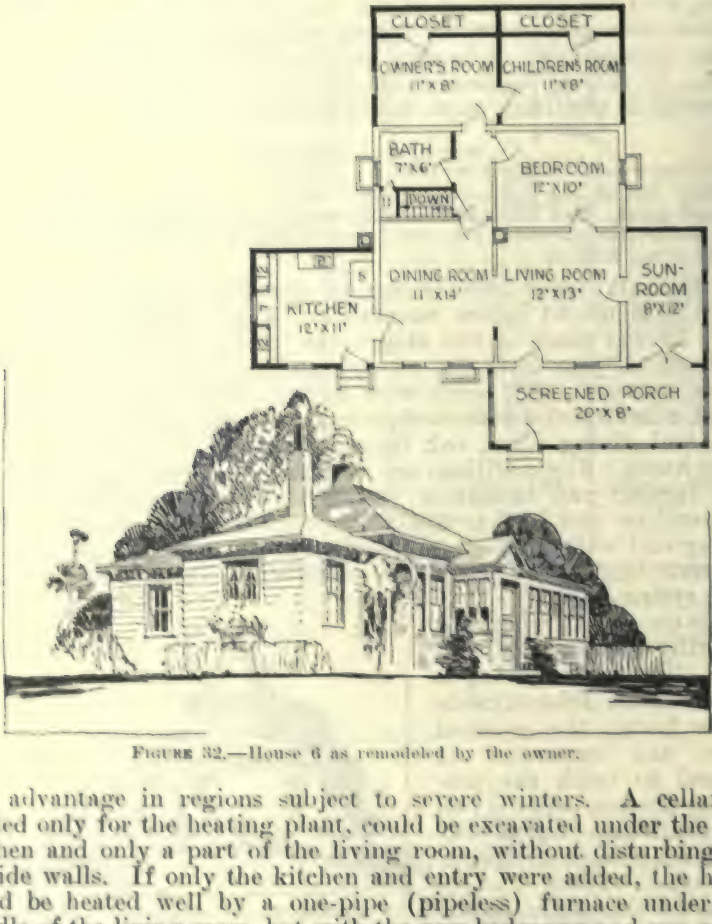


FIGURE 32.—House 6 as remodeled by the owner.

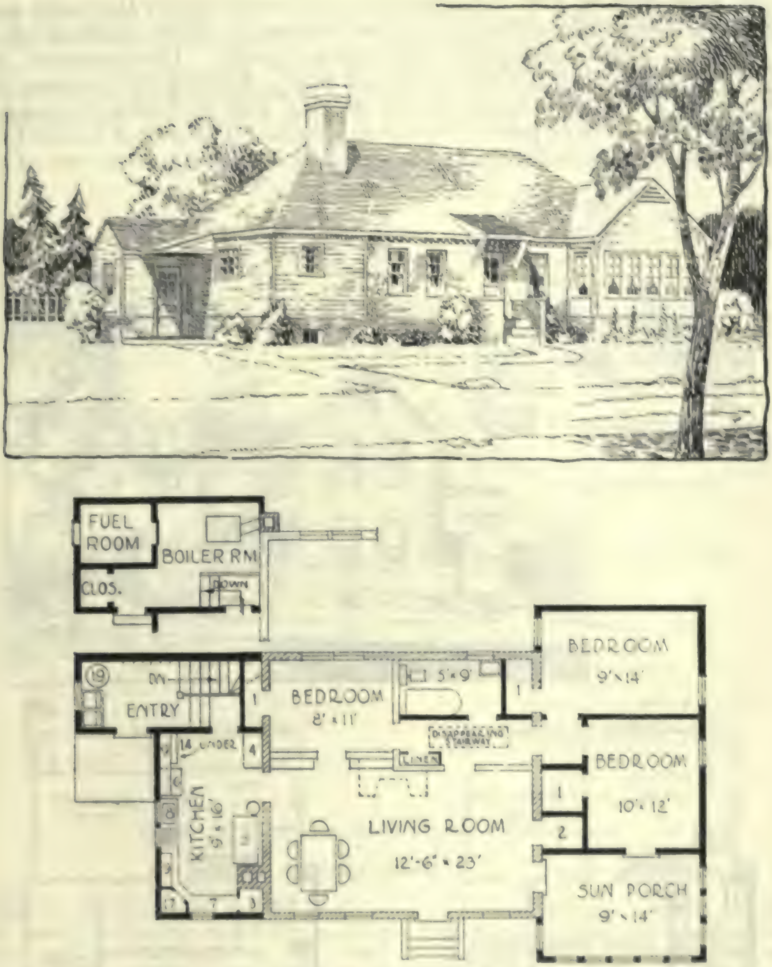


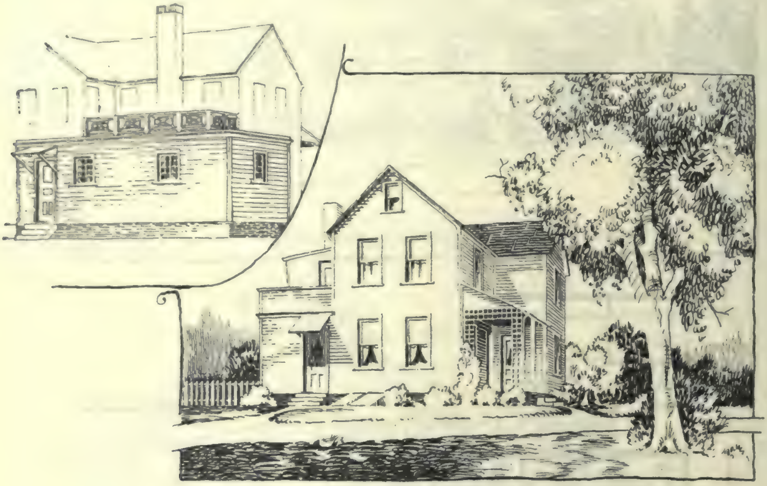
FIGURE 33.—Alternate design for modernizing house 6, and further alternative to place boiler in rear entry.

HOUSE 7 (OHIO)

Before remodeling, 6 rooms; added bathroom, kitchen, and heating plant; cash expenditure, $850; estimated full-purchase cost for work done, $1,000, including $425 for plumbing and heating; for alternate plan, $1,800, including $575 for heating and plumbing and $200 for electric wiring and fixtures.

This is a good example of remodeling a T-shaped two-story house consisting of combined kitchen and dining room, living room, and four bedrooms (fig. 34).

The major first-floor change was the conversion of the back porch into a long narrow kitchen, which the lady of the house likes because it saves much walking while doing the kitchen work. There is a pass shelf between the kitchen and dining room to aid in serving meals. As the door to the dining room is near the outside kitchen door, men coming into the house do not pass through the main part of the kitchen unless they go to the basement, which is fitted up as a laundry, men's washroom, and furnace room. The basement can be entered also through the bulkhead door. During the summer the men wash in the milk house before meals. The first-floor bedroom is furnished to serve as part of the living room. The owner would have preferred to remove the partition and make one large room out of the two, but a heating riser in this partition made that scheme impracticable. The second-floor remodeling includes a bathroom and an open deck over the kitchen, both of which have given satisfaction.



FIRST-FLOOR PLAN

SECOND-FLOOR PLAN

FIGURE 34.—House 7 as remodeled by owner. Inset shows kitchen wing of alternate plan (fig. 35).

This house is a good example of marked improvement obtained at moderate cost. Two features, however, might have been improved by a different design—the arrangement for reaching the inside basement stairway, and the exterior appearance. The alternate plan (fig. 35) shows a kitchen extension larger in plan but only one story high.

(See also inset in fig. 34.) This also provides a washroom and more direct entrance to the basement. The bathroom is shown on the first floor, which is generally considered the best location in a farmhouse. A washroom with toilet on the second floor is shown in the drawing. Good placing for electric fixtures and outlets is shown in figure 35.

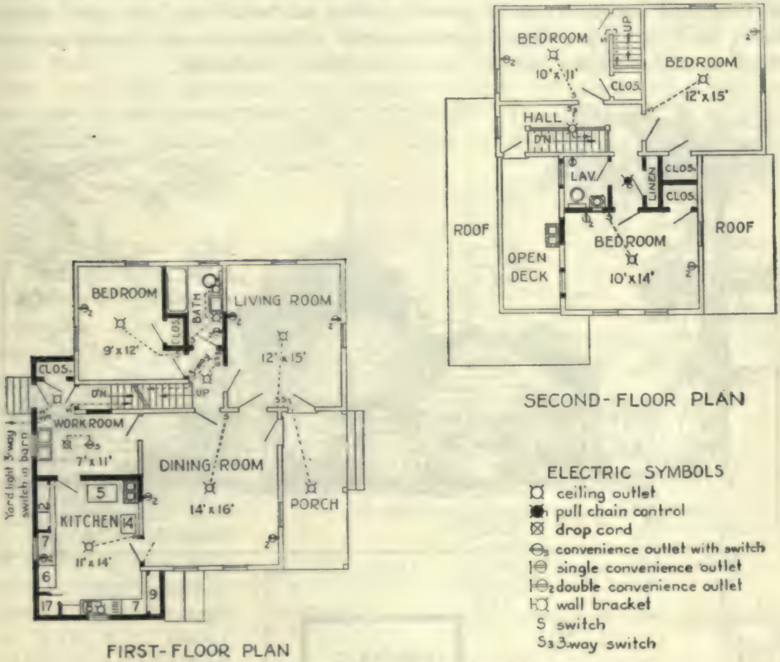


FIGURE 35.—Alternate plan for modernizing house 8.

HOUSE 8 (KANSAS)

Before remodeling, 4 rooms: proposed (1) adding kitchen, bedroom on the left, porch, and cellar under this addition, (2) installing bathroom and heating plant and remodeling living room, and (3) adding rear bedroom; estimated full-purchase cost for (1) $1,650; for (2) $700; for (3) $450; total $2,800.

The original house 8 was much like original house 6 but was of frame construction. The illustration (fig. 36) shows the remodeling suggested by the department of architecture of Kansas State Agricultural College. Most of the old structure is used, but the modernized dwelling is a completely changed house with improved exterior, three bedrooms, a centrally located bath, and a large living room. The work can be done in three stages, as indicated above; the dining alcove and entry are part of the first stage, and the second stage includes electric wiring and fixtures in the living room.

In this house communication between rooms is provided by the two halls. This is not uneconomical use of space in this instance because, as the designer pointed out, in remodeling houses existing walls and spaces must be utilized and this often makes it necessary to use more hall space than would be tolerated in a new design.

The new window arrangement in the old section of the house not only improves the exterior appearance but also gives better light to the living room. The design is generous in closet space. The plan of the front entry with wrap closet and dining alcove could be used in providing these features for other houses.

Remodeling as extensive as this would not be undertaken unless the original house were of good-quality material and in good condition. It is a very interesting example of how an old house may be transformed inside and out by a competent architect.

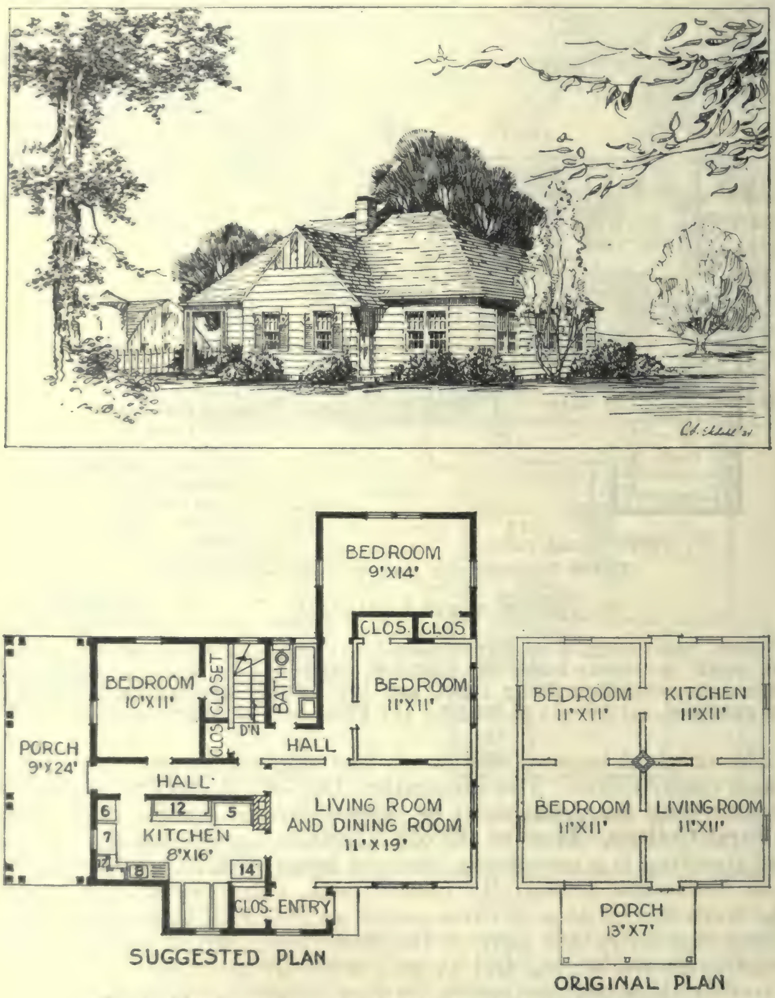


FIGURE 36.—House 8 remodeled and plan of the original house.

HOUSE 9 (CALIFORNIA)

Before remodeling, 5 rooms: removed partitions and added sunroom and entry; cash expenditure, $231; estimated full purchase cost of work done, $400; of alternate plan, $650.

The remodeling of this bungalow (fig. 37) calls attention to some of the disadvantages of this type of house for farm use. The change in the kitchen is most noteworthy, where spaces for work, storage, and everyday meals are now provided. The good-sized entry at the side increases the living area and is especially desirable because the former front entrance was on the far side of the porch from the driveway. The sunroom is utilized as a bedroom for the children and thus provides the third sleeping room which usually is needed in a farm home.

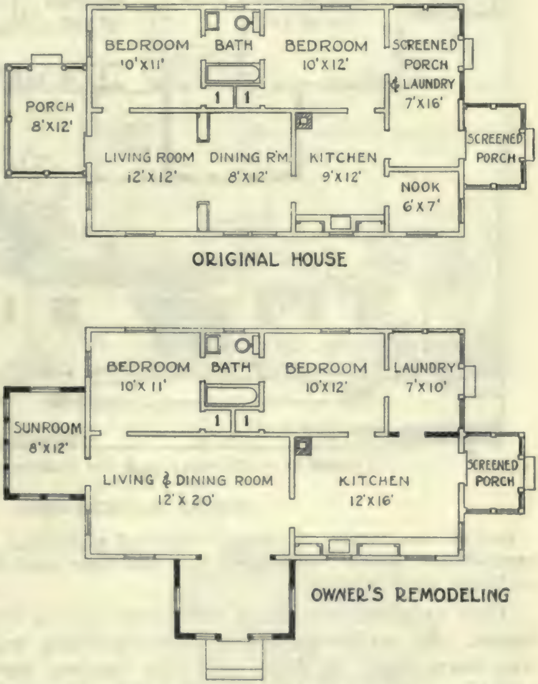


FIGURE 37.—Plan of house 9 before and after remodeling.

An alternate plan for remodeling this bungalow is shown in figure 38. The bathroom in this plan is arranged to give greater privacy than is obtained in the original house. A two-door bathroom is generally undesirable, as is the arrangement for entering one bedroom through the kitchen and one through the living room. Building out 2½ feet on the side of the house permits the arrangement shown, giving direct access from the living room into both bedrooms and the bath. Only the tub, washbowl, and clothes closets require new locations. Placing the tub under the window is not ideal, but this layout avoids moving the water closet. A door from the sunroom to the adjoining bedroom would give passage from the former to the bathroom without going through either living room or kitchen.

Another feature of the alternate plan is the kitchen arrangement. In the owner's scheme there are two rear entries side by side and a person must walk the length of the kitchen to reach the living room. The arrangement shown in figure 38 would shift the back porch and kitchen door onto the driveway side of the house, but screen them from the front entrance. The path from the porch door to the living room then would cross only a corner of the kitchen, and would not cause appreciable interference in the work area. The door and window merely exchange places, avoiding the necessity of excessive cutting.

The house could be heated by an oil-burning circulator heater in the living room and an electric heater in the bathroom.

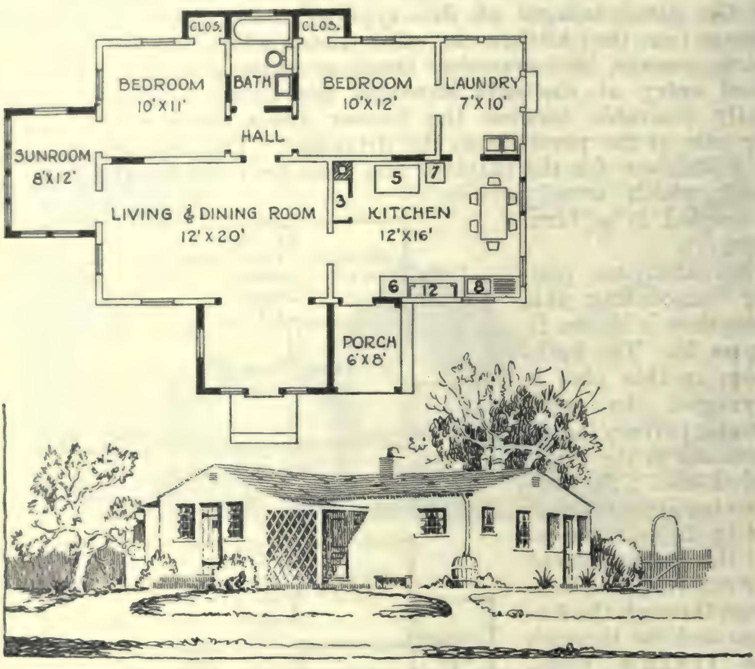


FIGURE 38.—Alternate plan for modernizing house 9.

HOUSE 10 (NEBRASKA)

Before remodeling, 5 rooms; removed partitions and added sunroom; cash expenditure, $1,650; estimated full purchase cost for work done, $2,500; for alternate plan, $3,000.

This original building evidently was a typical four-room square house. An early rear addition comprising workroom and back porch was torn away in 1928 and the lumber used in building a larger addition comprising a new kitchen, two bedrooms, and a modern bathroom (fig. 39). A basement was made under the new part.

This remodeled house illustrates some of the difficulties in planning a compact 1-story house with four bedrooms. The kitchen is not well lighted, because it has windows on only one side, and that is shaded by the porch. The pantry area, with its counters and built-in cupboards, is in the opposite corner of the kitchen from the stove. All travel to and from the bathroom and rear bedrooms, as well as all between the rear entrance and the other rooms, must pass through the kitchen and thus interfere with the housewife's work. The grouping of rooms around the kitchen, of course, aids in heating them from the range; yet a house as large as this could be better heated by a furnace.

A more satisfactory way to add the needed space to a house like this would be to remove the original addition and build a 2-story wing as shown in figure 40. This new wing would provide the kitchen, a utility room or laundry, a bathroom, 2 upstairs bedrooms, and a cellar with space for a central heating plant, thus completing a very livable 4-bedroom house. The illustration shows how the hip roof of the old building would connect with the new wing. During construction there would be very little interference with living in the old house. In later years the old part could be replaced with a new wing of 1½ stories that would include a

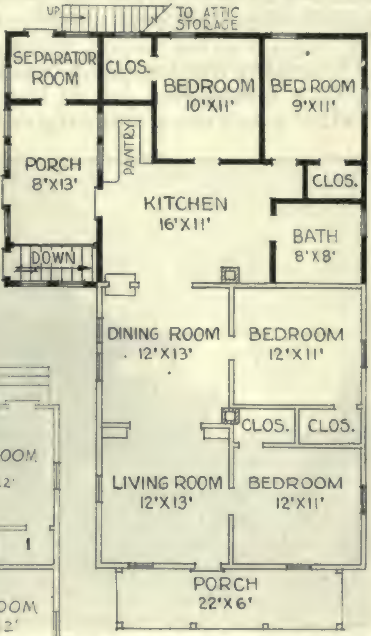
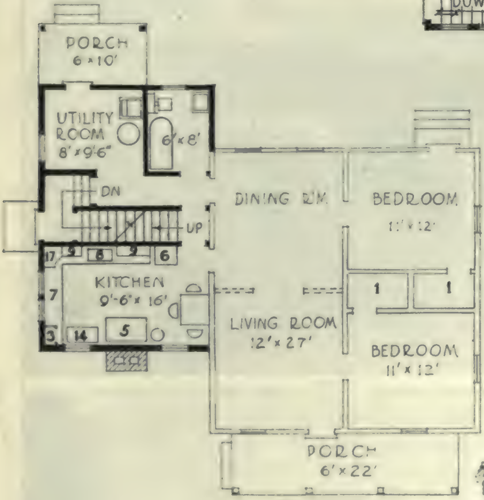


FIGURE 39.—House 10 as remodeled by owner.



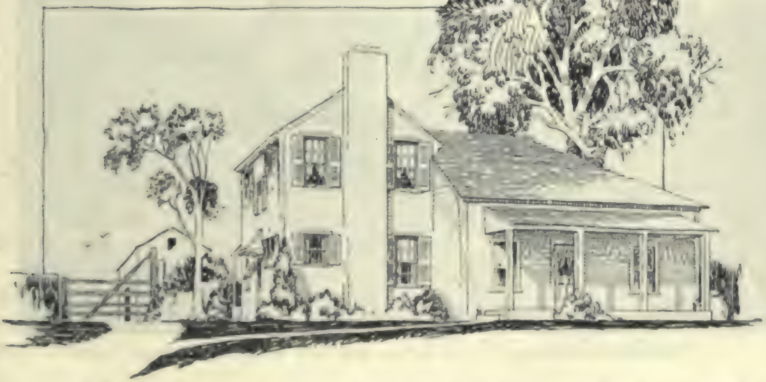


FIGURE 40.—Alternate design for modernizing house 10. (Plan for second floor not shown.)

dining room, a large living room, a downstairs bedroom or library, and 2 second-floor bedrooms.

HOUSE 11 (WASHINGTON)

Before remodeling, 3 rooms and bath; added first-floor bedroom, half second story, and basement; cash expenditure, $1,230; estimated full-purchase cost for work done $1,850; for alternate plan, $2,150, including $150 for one-pipe furnace.

The rather unpromising beginning and the very satisfactory result of a remodeling job in the Northwest are shown in figure 41. A cellar was dug, a downstairs bedroom was added to the kitchen wing, and two bedrooms were provided upstairs (fig. 42). The first-floor hall affords convenient passageway between all parts of the house. Adding the fireplace, cutting through two partitions, and

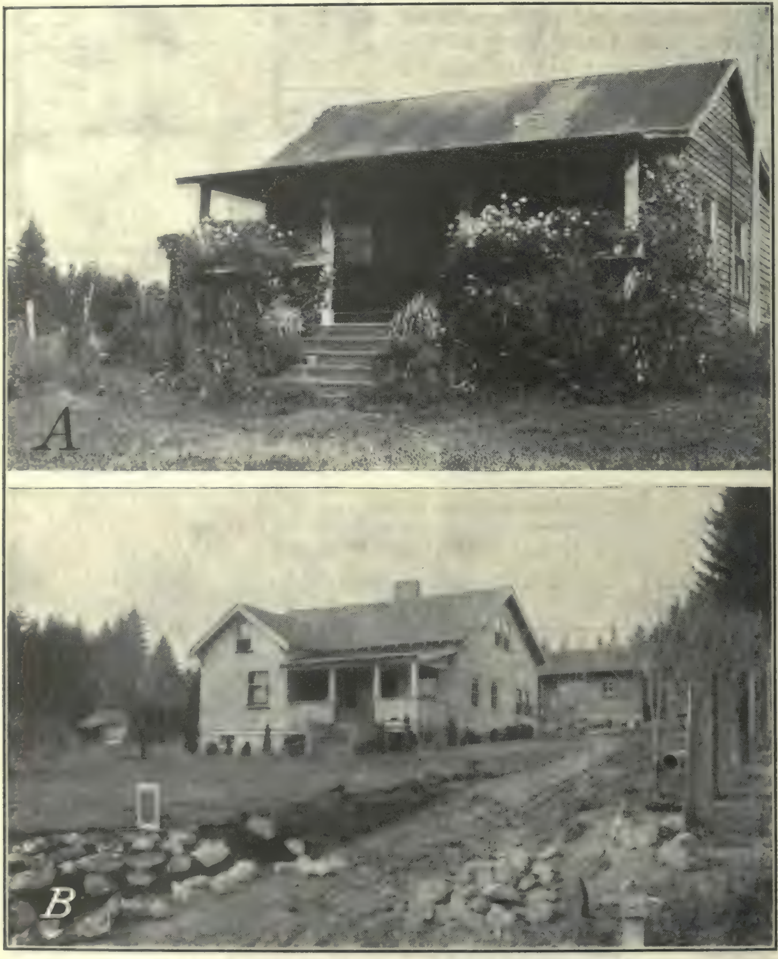
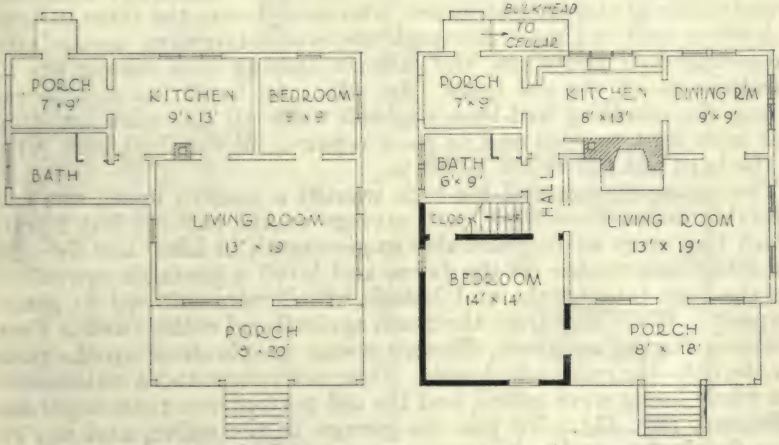


FIGURE 41.—House 11 (*A*) before and (*B*) after remodeling.

refinishing, comprised practically all the change made in the main part of the original house. The cost of the cellar was $340.

The owner feels the need of an inside stairway to the basement, more closet space, and a rearrangement of windows to give the house a better exterior appearance. Figure 43 shows an alternate plan for remodeling that would have provided the features desired by the owner while retaining the essentials of the design adopted. By placing the chimney as shown, space is gained in the kitchen, and an additional flue provides for a one-pipe furnace with the register at the foot of the stairs. The stairs and closets make the bedroom and living room slightly smaller, but still of comfortable sizes. As an alternate to the owner's arrangement, the partition between the dining room and the living room is shown removed, adding spaciousness to the arrangement and permitting the extension of the dining table into the living room should occasion demand. A wood box to be filled from outside could be built under the linen closet in the bathroom, by raising the closet floor 3 feet and cutting doors through the porch and kitchen walls.



ORIGINAL HOUSE

OWNER'S REMODELING

FIGURE 42.—First-floor plan of house 11, before and after remodeling.

Upstairs, dormer windows should be provided at the back to give cross ventilation to the bedrooms.

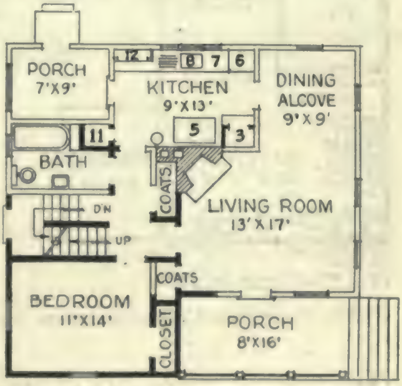


FIGURE 43.—Alternate plan for first floor of house 11.

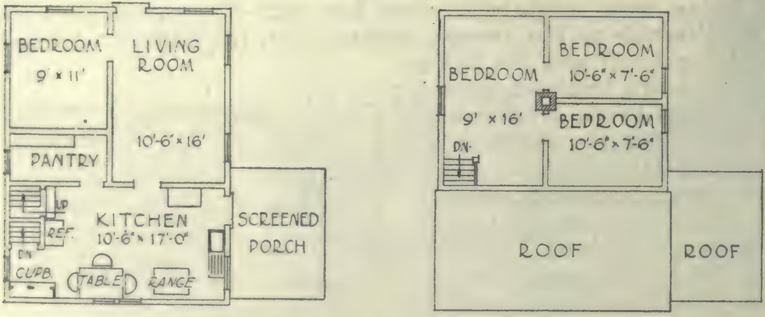
HOUSE 12 (WISCONSIN)

Before remodeling, 6 rooms; added 4 rooms, cellar, garage, stone veneer, and interior finish; cash expenditure, estimated total when completed, $1,500; estimated full-purchase cost, completed, $4,000 to $4,500.

The cover illustration shows the beginning and the near-completion of modernizing a pioneer farmhouse in central Wisconsin. The work is being done by a young dairy farmer and his wife, with a cash outlay very small for the result obtained but a large use of farm and local materials and of their own labor.

The original house was built in 1854 of native timber, by the great-grandfather of the present owner, who moved onto the farm in 1932. A kitchen used as a main thoroughfare, steep stairways, uncomfortable second-floor bedrooms, and difficult heating were among the inconveniences of the old home (fig. 44). As is all too common on farms, the dwelling had been slighted while all the other buildings had been kept painted and in good repairs. Water had been piped to the barn but not to the house.

The young farmer and his wife wanted a modern home, one considerably better than their cash savings would pay for but toward which they were willing and able to give much in labor and thought. He felled oak timber on the farm, and hired a portable sawmill to cut the logs into planks and boards which were allowed to season properly. With help from the State agricultural college and a Farm Housing Survey architect, the two young people drew up the plans for the new—or renewed—home. Four new rooms and a cellar under the whole house were added, and the old portion was rearranged and refinished (fig. 45). To put the garage in the cellar, and not too deep for drainage, the old house was raised before the new part was built. The exterior veneer is native stone procured by razing an abandoned house nearby.



· FIRST-FLOOR PLAN · · SECOND-FLOOR PLAN ·

FIGURE 44.—House 12 in 1933, before it was remodeled. (See cover illustration.)

The new kitchen, finished in native hardwood, is a model of compactness and convenience (fig. 46)—a place where housework may easily become a pleasure instead of drudgery. It is situated in the corner of the house nearest the barn.

The new living room (fig. 47) with its stone fireplace, its hardwood floors, and the walls paneled in cherry cut on the farm some years before, is a secure and comfortable place to enjoy a quiet evening or a visit with friends.

The new stairway and the bathroom convenient to both upstairs and downstairs are also major features in the achievement of this now very comfortable home.

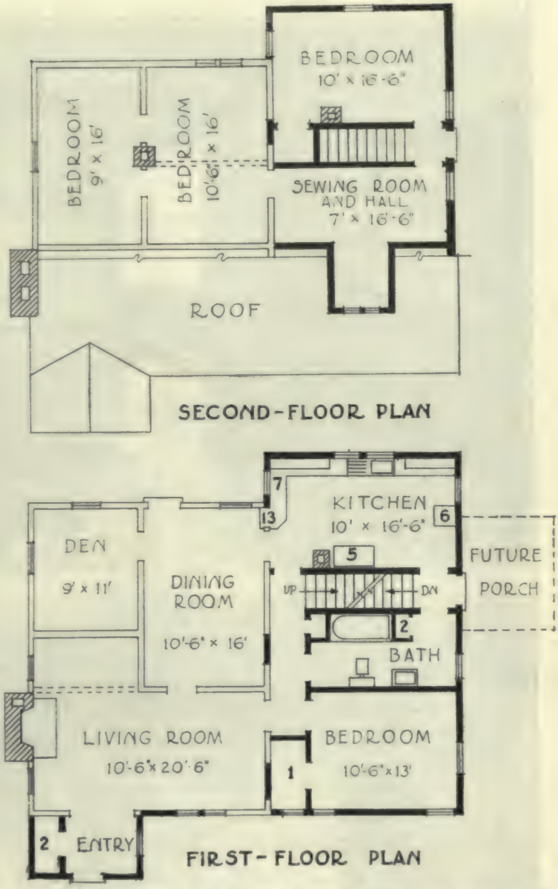


Figure 45.—House 12 in 1935, with remodeling completed to stage shown in cover illustration.

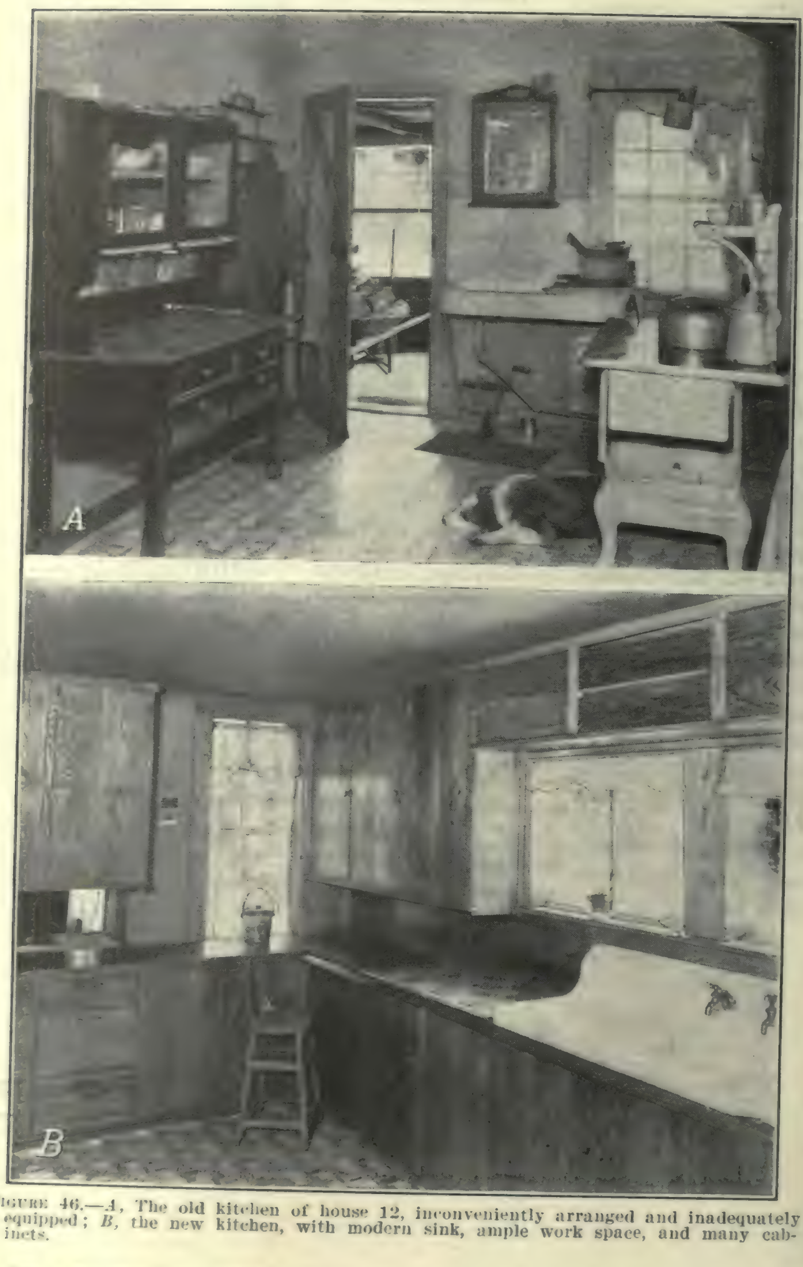


FIGURE 46.—*A*, The old kitchen of house 12, inconveniently arranged and inadequately equipped; *B*, the new kitchen, with modern sink, ample work space, and many cabinets.

This house illustrates how attic space under a low roof may be utilized for comfortable bedrooms. In the old house the upstairs rooms were very cold in winter and very warm in summer. In remodeling, insulation was used under the roof and on the gable walls to give greater protection from heat and cold. This and the installation of a furnace made the house much more comfortable during its first winter. The insulation and the better ventilation to be obtained by the additional windows should make the upstairs more livable in summer.

The entire work of modernizing this house is being done by the owners and one skilled builder, with occasional extra help.

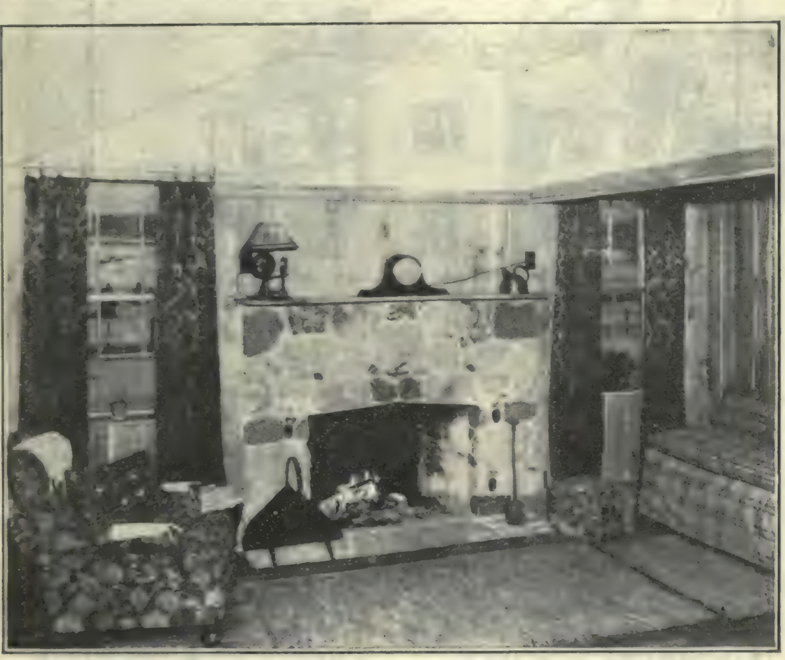


FIGURE 47.—A cheerful corner of the new living room in house 12.

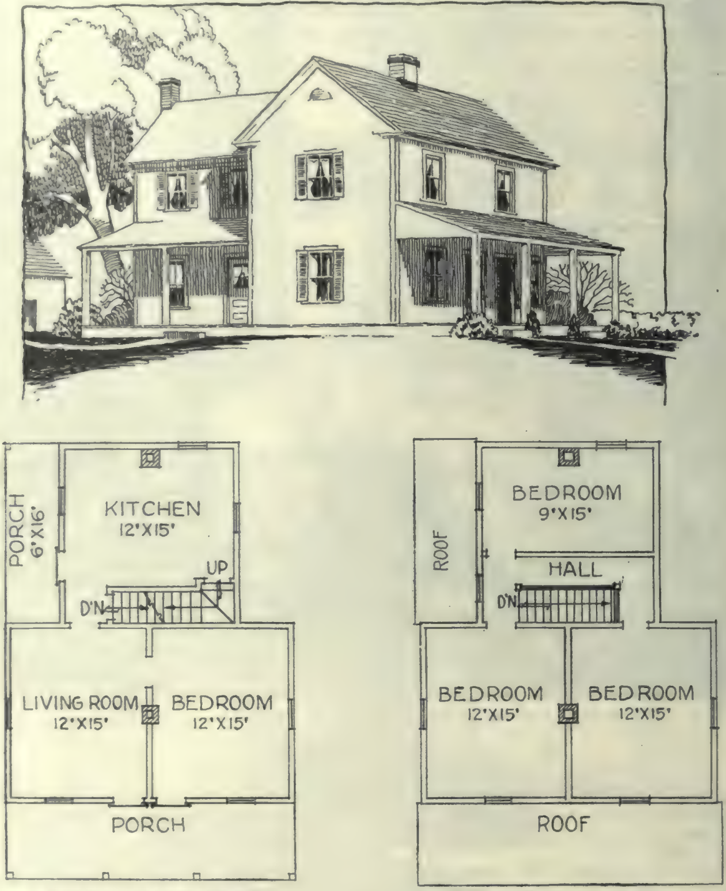
HOUSE 13 (OHIO)

Before remodeling, 6 rooms; suggested adding a bathroom, laundry, and closets; estimated full-purchase cost for suggested plan $900 or for alternate plan $950, including $450 for plumbing and heating.

Another design for remodeling a two-story T-shaped house has been proposed by the department of agricultural engineering of Ohio State University. The original house (fig. 48) has plenty of sleeping space in the four bedrooms, but it has no closets or bathroom and the living room is rather small.

The suggested remodeling proposes an addition adjoining the kitchen (fig. 49) to provide a laundry or workroom at the kitchen level and a bathroom three steps higher, off the stair landing. There the bathroom is convenient to both upstairs and downstairs rooms. A doorway and a flight of three steps from the stair landing to the downstairs bedroom shortens the travel from that room to the kitchen or the rear entry.

With the kitchen arranged as shown, the work is done in the corner away from the doors, so men or children going through will interfere little with the preparation of meals. There is room in the kitchen for a small dining table for everyday meals, and company dinners can be served in the living room. The alternate plan (fig. 49) is even more compact and would keep traffic almost entirely out of the work area, at the cost of a slight reduction in working space.



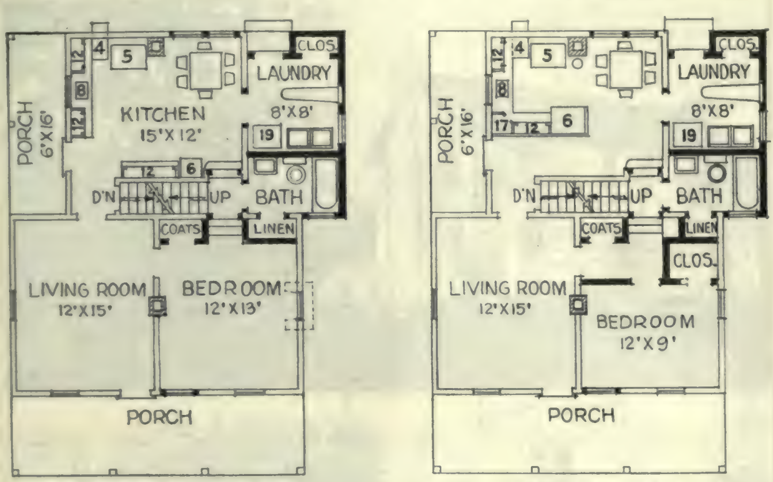
FIRST- FLOOR PLAN SECOND-FLOOR PLAN

FIGURE 48.—House 13, as used in 1934.

The downstairs bedroom would be used somewhat according to the size and habits of the household. It might be furnished and used as part of the living room if the upstairs bedrooms provided sufficient sleeping space. In this case double or French doors between these rooms might be desirable; or the two rooms might be made into one large living-dining room by removing the chimney and at the end of the bedroom building a fireplace with flue for the furnace. If, on the other hand, the downstairs bedroom were wanted regularly for sleeping, greater privacy could be obtained and a closet secured by making a small hall from the living room to the stairway as shown in the alternate plan.

The second-floor alterations suggested consist only of building 4 closets, 1 in a corner of each bedroom and 1 opening off the hall. To use wardrobes, instead, would be a little cheaper.

A piped warm-air, hot-water, or steam heating system would be most satisfactory for the house remodeled as shown in the suggested plan, although for the alternate plan a one-pipe furnace with the register in the hall probably would serve.



SUGGESTED PLAN ALTERNATE PLAN

FIGURE 49.—First-floor plans for modernizing house 13.

HOUSE 14 (NORTH CAROLINA)

Before remodeling, 5 rooms; added sunroom, bathroom, dressing room, electricity, and new partitions; cash expenditure for carpentry and materials $1,600, plumbing $200, for water and sewerage systems $250, for electric house wiring and fixtures $150, for extending power line $650.

A graphic story of restoration in a setting strongly reminiscent of ante-bellum days is told by the accompanying illustrations. The old house seemed to express a note of sadness, due to years of neglect (fig. 50 *A*). The interior had few partitions, and in most of the building the studding was exposed. Beneath all this discouraging appearance, however, there existed a dignity and charm that offered a rich reward to the owner who should restore the building. The house is especially interesting because it is of a type found widely distributed through the South.

The improvements made by the owner are shown in figure 51 (the heavy lines representing new walls and partitions). An addition at the rear of the two-story wing provided a bathroom, dressing room, and closet on the first floor, and a sunroom above with storage space. New partitions upstairs and downstairs divided the house into rooms of convenient size, and provided closets for all bedrooms and the sewing room. A kitchen pantry was built on the rear porch, the remainder of which then was screened. The stairway was rebuilt. The front porch adds to the livability of the house.

The original house is a nicely proportioned example of colonial architecture, and some persons would feel that the shed-roofed, two-story addition somewhat mars the exterior appearance unless hidden by trees. A simple scheme for remodeling this house while maintaining the original style is shown in figure 52. The bathroom addition but one story in height would not detract from the appearance of the two-story wing. The second-floor doorway over the front porch suggests that the porch be roofed with a flat deck guarded by a railing, instead of having a pitched roof as pictured in figure 50, *B*, in order to give sun space that in large degree would compensate for the omission of the sunroom shown in figure 51. The present remodeling is very good, and the house will be even more attractive when the grading and planting around it are completed, but the alternate plan would be more in harmony with the original colonial style. The closet problem is solved in a simple way that

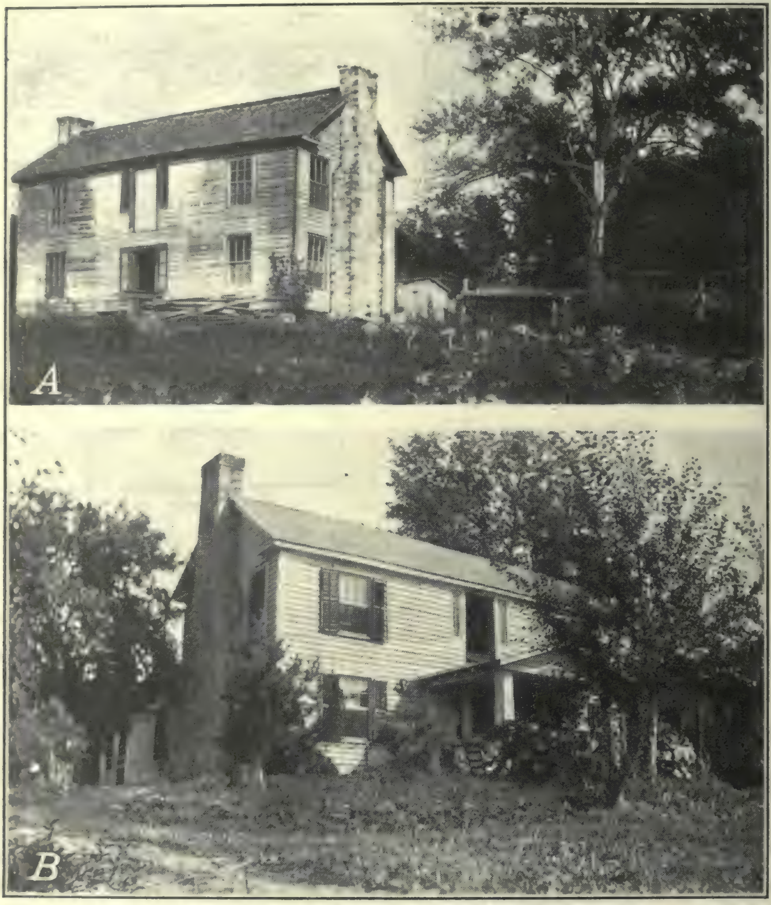


FIGURE 50.—House 14 (*A*) before and (*B*) after remodeling.

spells economy in construction. Storage space can be obtained in the attic by the use of a trap door or a disappearing stairway.

The stairs run up toward the back of the house. They would be more convenient if reversed to run up toward the front, but that cannot well be done because the hall is too short to give clearance over the front door unless the stairs were made undesirably steep or winding. While the house is heated by fireplaces only, the wall between living room and stairway hall is needed to keep the living room comfortable in cold weather; if a central heating plant were installed, the omission of this wall would improve the proportions of the room.

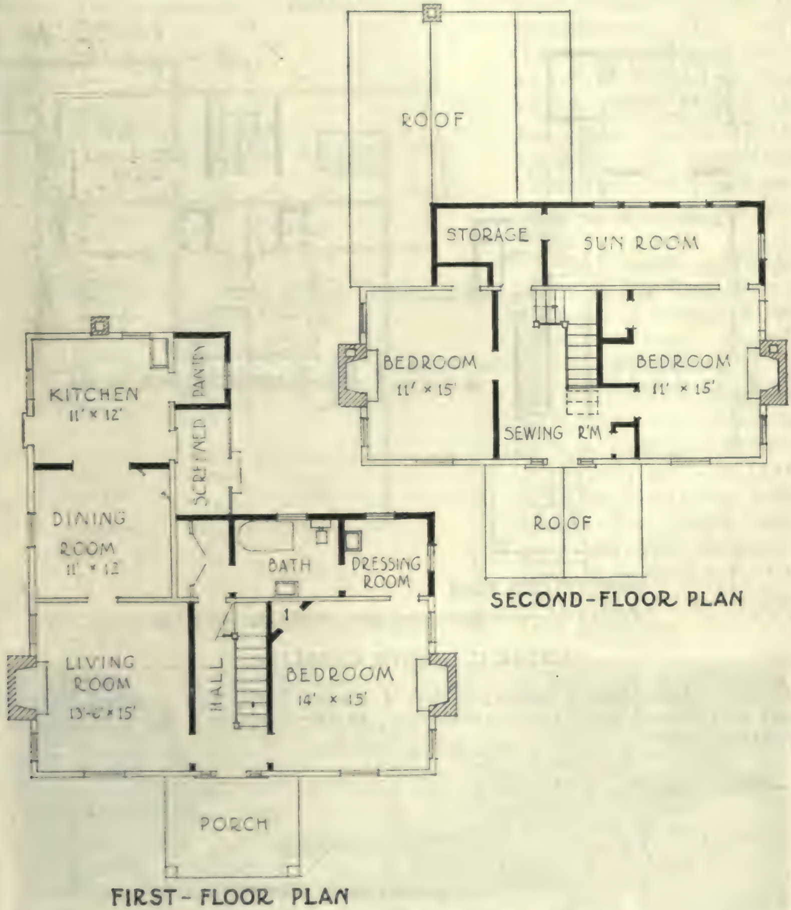


FIGURE 51.—Plan of house 14 as remodeled by the owner.

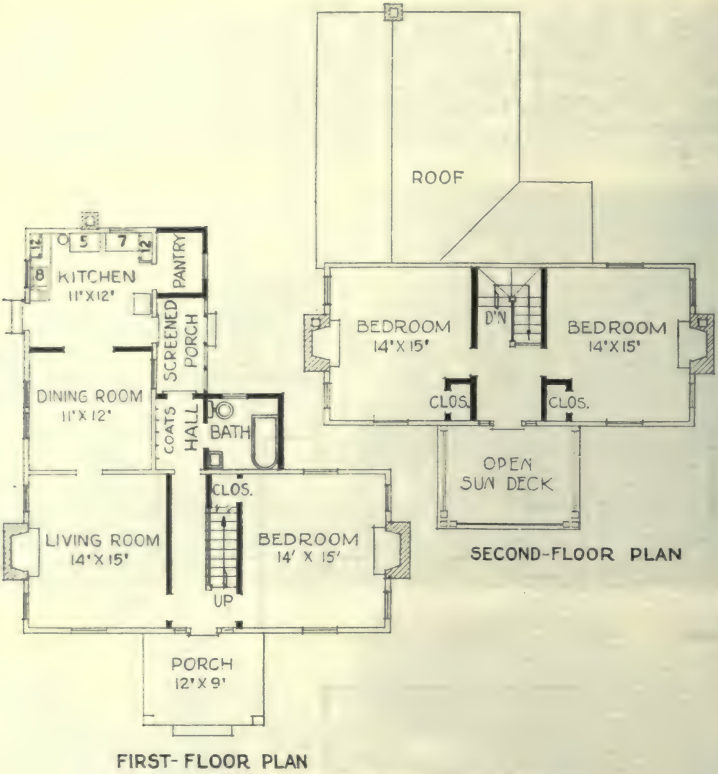


FIGURE 52.—Alternate plan for remodeling house 14.

HOUSE 15 (NORTH CAROLINA)

Before remodeling, 5 rooms; added 4 rooms, bath, and porches, changed stairs and altered roof; cash expenditure, $1,000; estimated full-purchase cost, $3,500 to $4,500.

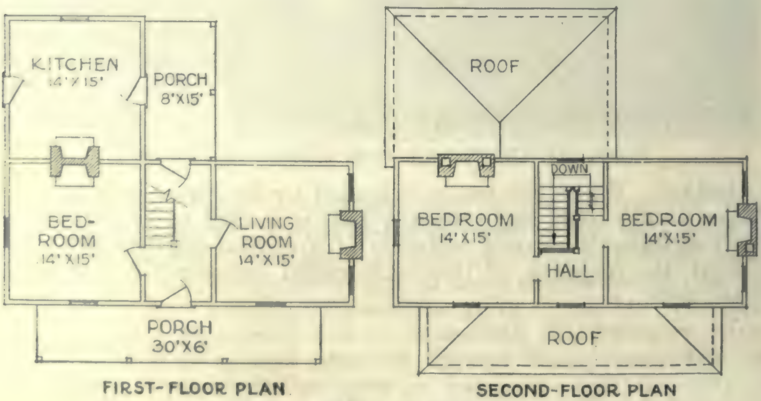
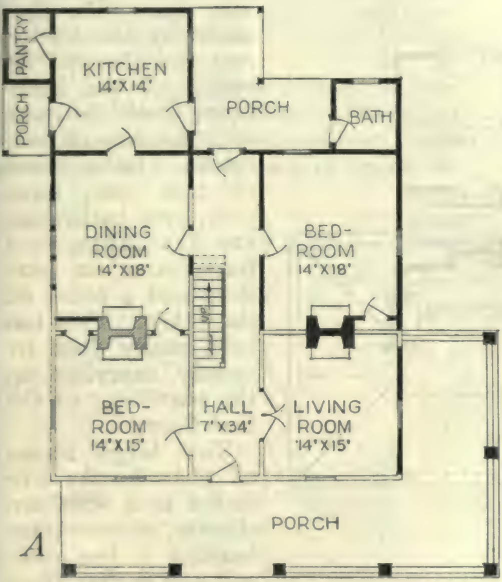


FIGURE 53.—House 15 before remodeling.

A family of 10 in only 5 rooms made this house (fig. 53) badly crowded. Before remodeling it was much like house 14, and it could have been changed into a 3-bedroom dwelling in much the same way. To obtain 6 bedrooms for the family, the owner followed the simple expedient of filling out the ell to form a square 2-story house and added a 1-story kitchen wing. The old roof line was altered and a new porch added to give the house a modern, pleasing appearance (fig. 54). The two central chimneys are placed to heat every room except the kitchen. Much of the lumber was cut from timber on the place and sawed by the owner's mill.

The room arrangement of the first floor is planned in simple, direct style, without complicated partitions. A square building like this is economical in construction as well as in upkeep. Some people would favor placing the living room beside the dining room and the two bedrooms next to each other, with the bath in a more central location.



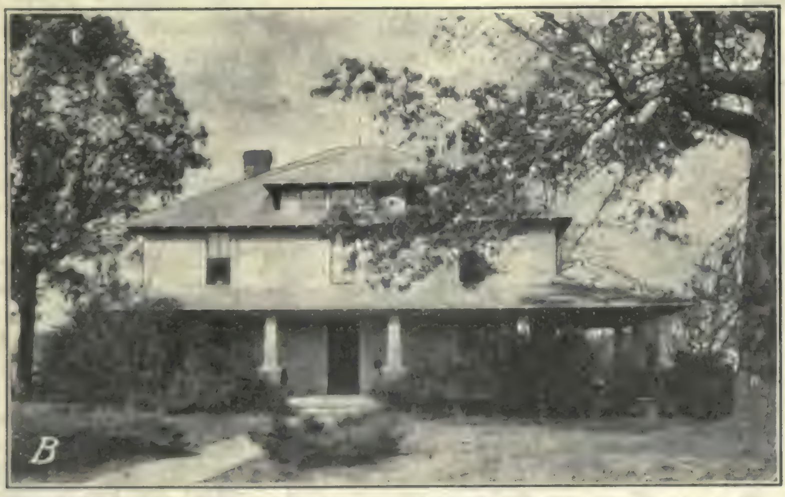
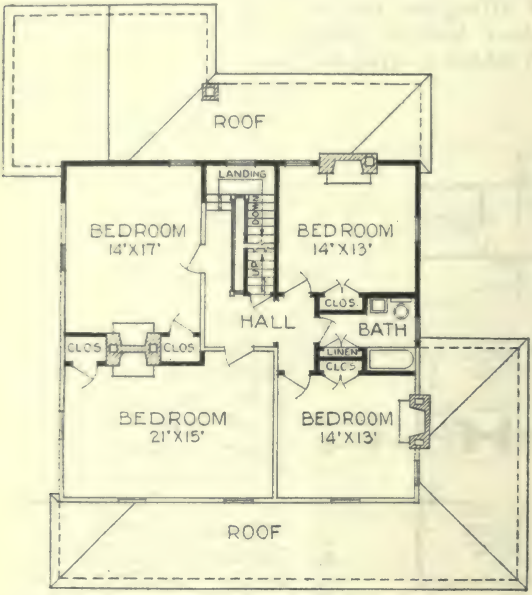


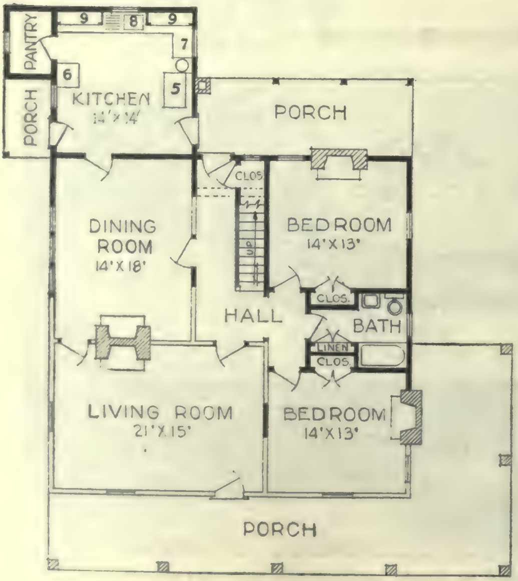
FIGURE 54.—House 15 as remodeled by owner (second-floor plan not shown); *A*, Plan of first floor; *B*, front view.

An alternate plan is shown in figure 55. In this the stairway is moved back and the left front room and the hall are thrown together to form a large living room. The front room at the right is made a bedroom, and a bedroom and bathroom fill out the ell. This change in the stairs would cost little if any more than that made by the owner, and the changed location of the bathroom would be more convenient to all bedrooms. In a house of this size, however, two bathrooms are desirable, or a bathroom on one floor and a toilet on the other. This has been easily done by merely carrying up the partitions of the first floor.

The large rooms of this house are suited to a southern climate, where winter heating is less difficult and shelter from the summer warmth is more important than in the North. Fireplaces are provided in all bedroom. A central hot-water heating system could be installed, with the heater placed beside the dining-room fireplace, and the new chimney in the rear bedroom omitted. This would add much to the comfort of heating the house in cold weather, and the cost would be partly offset by the saving in chimney construction and maintenance.



SECOND-FLOOR PLAN



FIRST- FLOOR PLAN

FIGURE 55.—Alternate plan for modernizing house 15.

A kitchen arrangement particularly suited for using an electric or gas stove is shown in figure 56. This avoids the uncomfortable warmth from a wood range, is more compact, and brings the working area closer to the dining table.

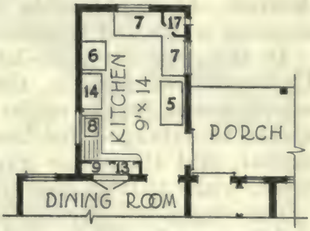


Figure 56.—Alternate kitchen arrangement for house 15, with electric stove.

HOUSE 16 (ILLINOIS)

Before remodeling, 7 rooms; suggested replacing 1-story wing with 1½ story addition containing 4 rooms, bath, and toilet; estimated full-purchase cost $3,000 to $4,000, including heating, plumbing, and electric wiring for entire house.

This was originally a 4-room, 2-story house with a 1-story kitchen wing, to which various additions have been made to obtain the house shown in figure 57.

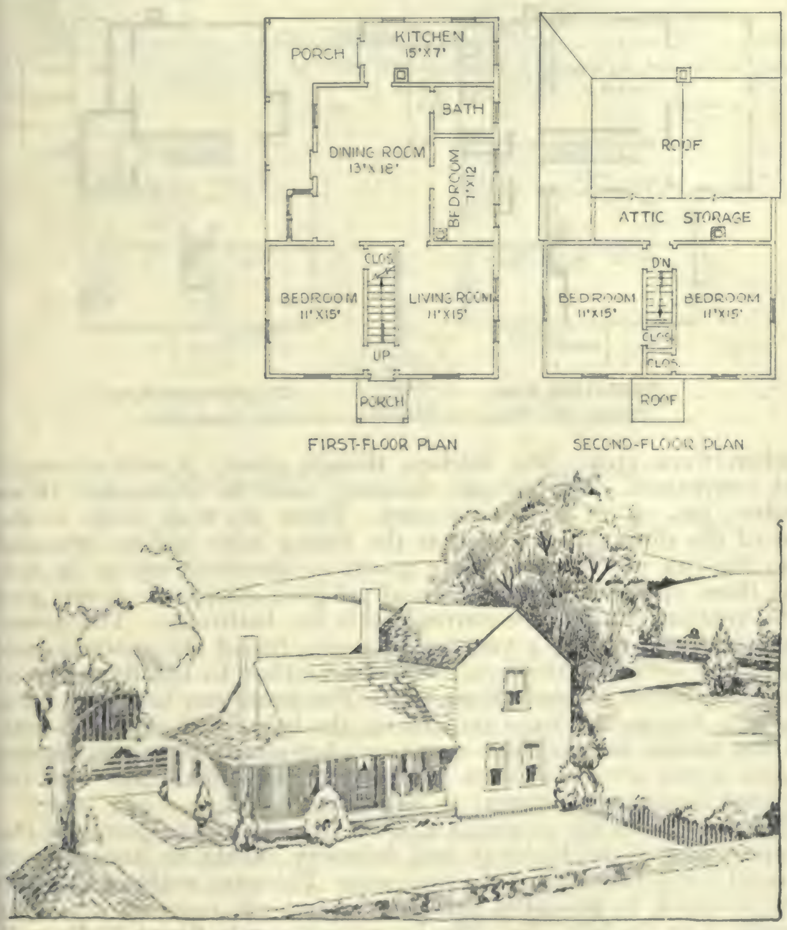
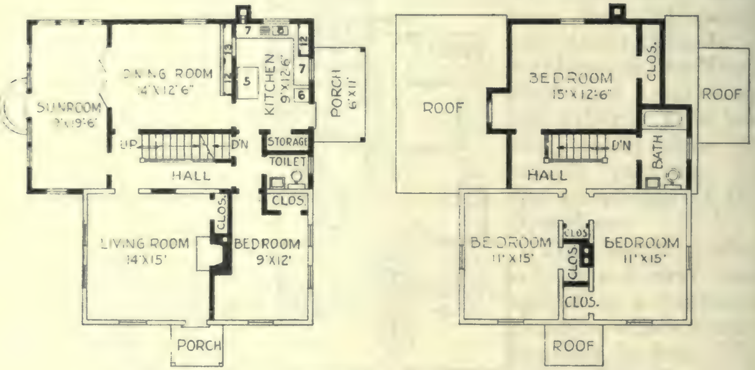


Figure 57.—House 16 in 1934.

In remodeling a building of this kind it is a question whether to tear away completely the 1-story wing or to use parts of the old walls and floors. The decision should depend largely on the condition and arrangement of the old house and on the new facilities desired. It is generally easier to plan new than to try to utilize existing walls and spaces.

In the plan for remodeling this house (fig. 58) suggested by the University of Illinois, the entire 1-story part would be removed, which would permit easier excavation of the cellar, and the material would be salvaged for use in rebuilding. The stairs would be removed, and the space gained downstairs made part of the living room, while that gained upstairs would be used for closets.

The suggested arrangement has several good features. Men or children coming in at the kitchen door have easy access to the dining room, living room, stairs, or toilet without passing through the kitchen work area. The kitchen, though small, is well arranged and convenient. The outside chimney could be eliminated if an electric, gas, or oil stove were used. There are wide doors at the end of the dining room, so that the dining table can be extended onto the sun porch when many guests or threshers are to be fed. The three upstairs bedrooms are all of good size, have closets and cross ventilation, and are convenient to the bathroom. The downstairs bedroom also is a very usable room, but if the upstairs bedrooms are sufficient this space could be added to the living room and the fireplace located at one end. The house can be heated by a one-pipe furnace with the radiator in the hall which connects with all the rooms, but a piped warm-air, hot-water, or steam-heating system would give more even distribution of temperature. The remodeled house might appear as in figure 59.



FIRST-FLOOR PLAN **SECOND-FLOOR PLAN**

FIGURE 58.—Suggested plan for remodeling house 16.

The relation of the rooms of a house like this to the points of the compass and to the highway and driveway should be studied with especial care on account of the sun room. This plan could easily have been reversed, to place the living room and sun room on the right instead of on the left side. The house as shown in figure 58 fits well in locations on the west side of the highway, while the reversed plan fits better in locations on the east side of the highway (fig. 60).

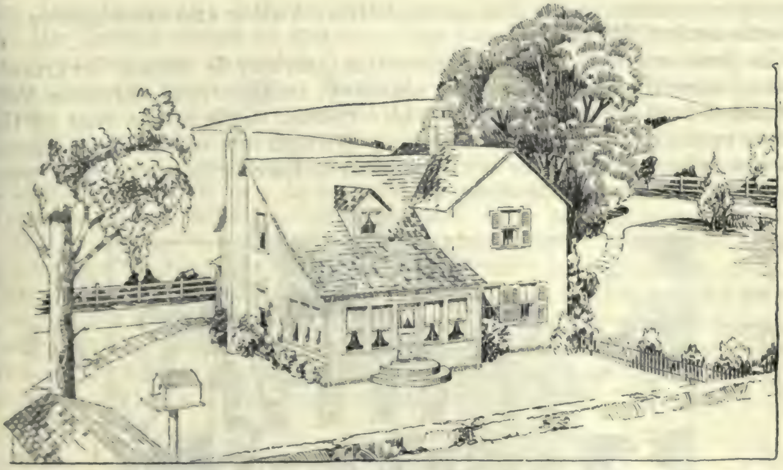
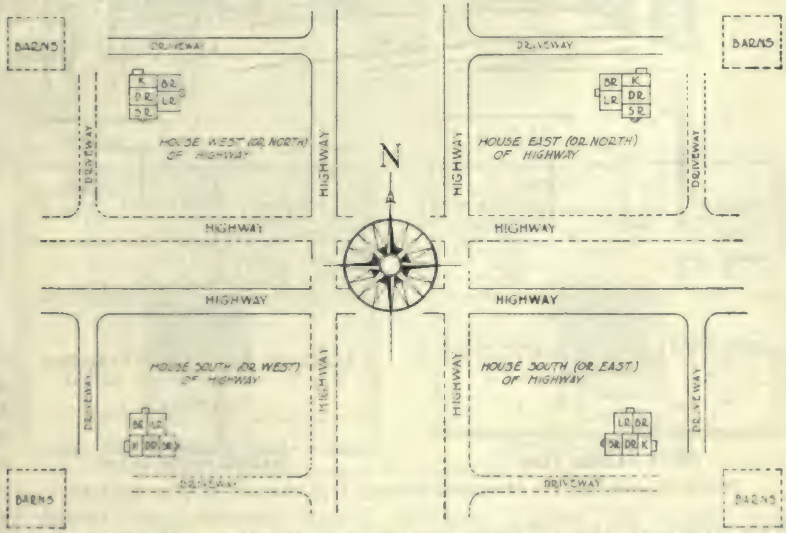


FIGURE 59.—Sun room view of house 16, according to suggested remodeling plan.


BARNS
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HIGHWAY
HOUSE SOUTH (OR WEST) OF HIGHWAY
HOUSE SOUTH (OR EAST) OF HIGHWAY

FIGURE 60.—Variations in the placement of house 16 according to location with respect to highway.

HOUSE 17 (MASSACHUSETTS)[8]

Before remodeling, 8 rooms; suggested rearrangement of interior and installation of equipment; estimated full-purchase cost $1,600 to $2,000, one-half for heating, plumbing, and electric wiring.

Eighteenth-century houses in New England were heated by means of open fireplaces, and cooking was done over an open fire and in ovens built into one or both sides of the huge kitchen chimney. For this reason the houses were built around chimneys large enough to allow for fireplaces in nearly every room (fig. 61). This type of house is common in the Connecticut River Valley and elsewhere in the Northeastern States.

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[8] This example of remodeling is furnished by the department of agricultural engineering, Massachusetts State College.

In these central-chimney houses the stairway is almost invariably found directly in front of the chimney, in the front entrance hall. If the second story was divided into rooms, those in the rear of the house could be reached only by going through one of the front rooms, except where rear stairs leading from a rear first-story room were built, as was frequently done.

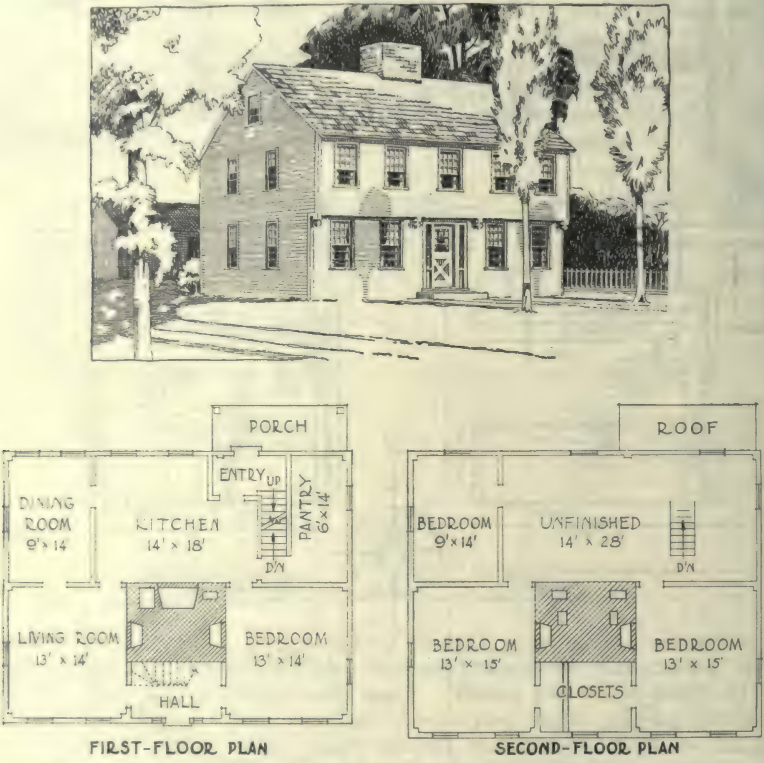

FIGURE 61.—House 17, of central-chimney type common in New England.

The structure also of these houses is distinctive. With the tradition of Old England's method of framing wood houses behind them, the earlier builders rarely did other than to hew the main frame from oak, mortising and tenoning all joints and securely bracing all main timber intersections in both horizontal and vertical planes. The weight of the house is carried on this frame, and because the partitions bear no load they can be rearranged more easily than in other types of houses.

The farmhouse shown in figure 61 is typical of the central-chimney type, except for the omission of the front stairs. A front stairway nay have been built in the original house, and subsequently removed, ut the lay-out seems to indicate that the builder wished to avoid he inconvenience caused by a front stairway and provided only hat from the rear entry. With one large unfinished room in the econd story, presumably unused for sleeping, this made for better ir circulation upstairs notwithstanding the rear entry approach. The house as it now stands shows the effect of changes in methods f heating and cooking. As is commonly found, stoves have replaced ireplaces which, when no longer needed, have been bricked up.

The plans for remodeling (fig. 62) shows how the interior could e changed to provide modern conveniences and comforts for a ypical New England farm household. A more convenient stairway s suggested, permitting the finishing of four bedrooms and a bathoom upstairs, with no room serving as a hallway to another. The kitchen would be moved to the corner, where it would have light n two sides; the living room would be enlarged; the dining room

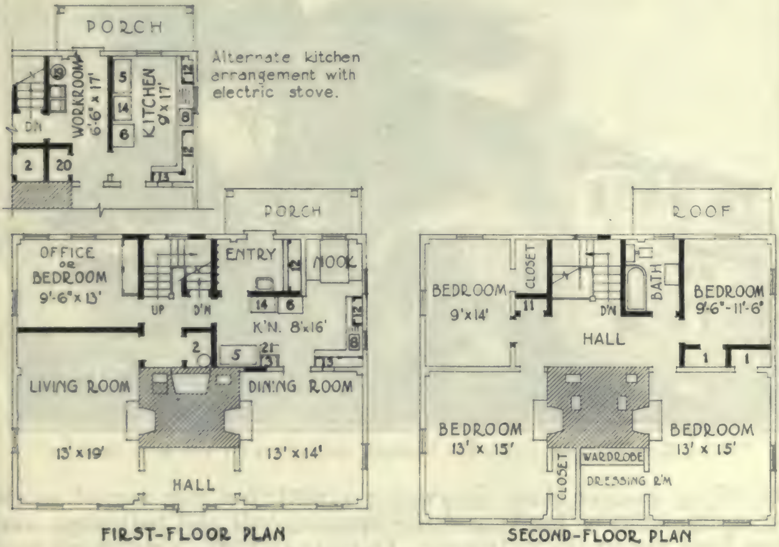

Figure 62.—Suggested remodelling for house 17.

nd downstairs bedroom would exchange places. A small entry eside the kitchen would provide a place for men to hang clothes nd wash before coming into the main part of the house. Where heap electric current is available, the kitchen and workroom could e made even more convenient by adopting the alternate arrangement hown in figure 62.

With a new central heating plant installed in the basement, some f the fireplaces could be reopened, the mantels cleaned and refinshed, and much of the spirit and atmosphere of a past age recapured and enjoyed amid the conveniences of modern times.

HOUSE 18 (MICHIGAN)[9]

Before remodeling, 11 rooms; installed stairway, bathroom, and fireplace and added screened porch.

House 18 (fig. 63) has been in satisfactory use by two farm families for several years, the owner and his son having separate apartments in it. Each family has a kitchen, dining room, and living room on the first floor, and bedrooms on the second floor. There is communication between the two apartments only through the basement.

The remodeling has been a rather gradual process. Porches were screened, a laundry room was added, a bay window was built on, and a bathroom was installed. As it happened, the house developed in such a way that when the two-family arrangement became desirable the structural changes needed were only minor.

The alterations made to complete the separate apartments are shown by the plans (figs. 64 and 65). The music-room wing was shut off by closing three doorways; a partition was moved so the new stairs could be built; and the upstairs hall and bathroom were taken from one of the bedrooms. Outside and inside stairways were built to the basement, where laundry equipment was installed; a screened back porch gives a comfortable working space in summer and protection to the kitchen doorway in winter; the fireplace adds cheer to the new living room. Each apartment has its own one-pipe furnace. These changes were made over a period of 6 or 7 years.

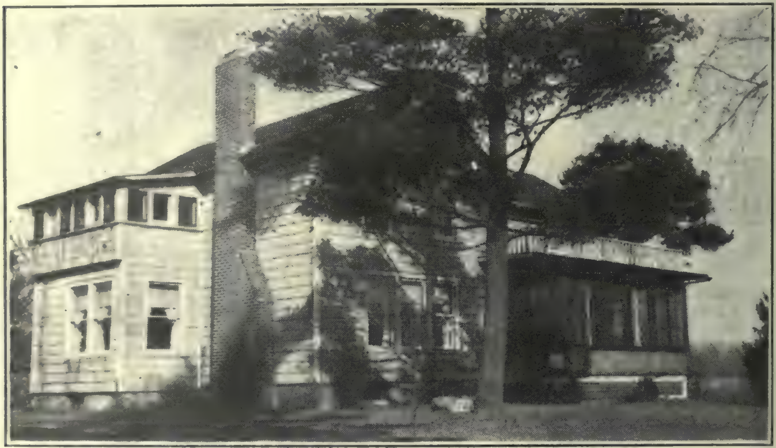

FIGURE 63.—House 18, which has separate apartments for two farm families.

The changes made in this house have provided economical but adequate housing for both families, with satisfactory privacy for each family, including independent control of its own heating plant. The front porch and the basement are the only parts of the house used in common. Instead of money being put into a new structure, it was put into improvements and conveniences that have made the old home a very pleasant and comfortable place in which to live.

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[9] Information furnished by department of agricultural engineering, Michigan State College.

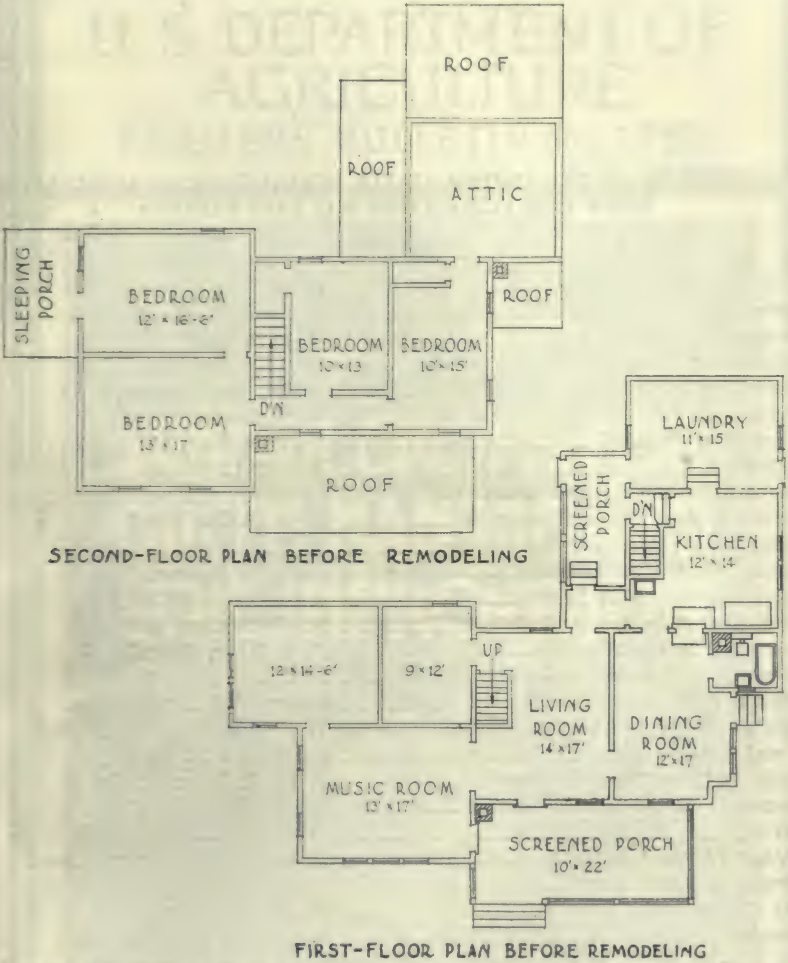

FIGURE 64.—House 18 before the remodeling that made it into separate apartments.

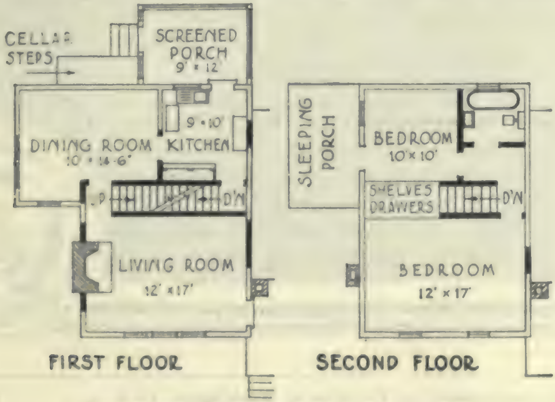

FIGURE 65.—Remodeled wing of house 18.

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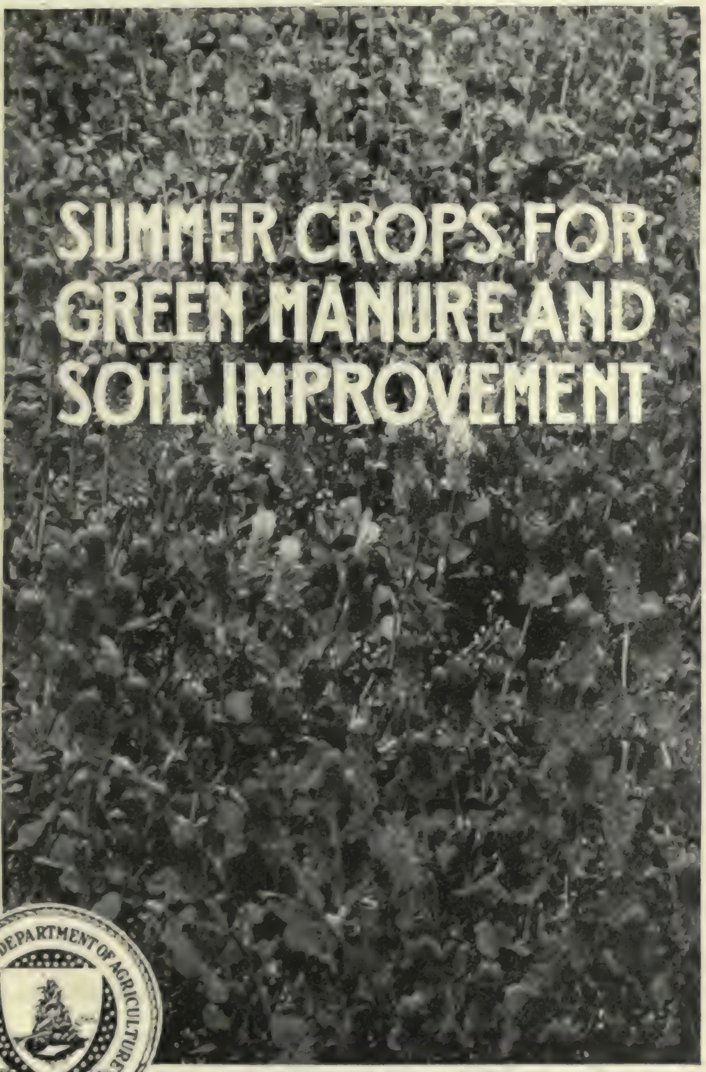

SUMMER CROPS FOR GREEN MANURE AND SOIL IMPROVEMENT

THE CROPS most commonly used for summer green manure and soil improvement are alfalfa, red clover, soybeans, cowpeas, velvetbeans, sweetclover, crotalaria, and lespedeza. These are all legumes, which take nitrogen from the air through symbiotic bacteria that are found in the nodules on the roots.

When the object of green manuring is primarily to supply organic matter, nonlegumes such as Sudan grass, mustard, sorghum, or other plants which make heavy yields may be particularly serviceable.

The use of legumes in rotation as one of the regular cash crops is one of the most economical ways of maintaining soil fertility and crop production.

The use of a summer crop exclusively for green manure generally is not advisable, but under special conditions may be advantageous.

Summer legumes in mixed plantings with other crops, and in rotations where they are used as hay, enrich the soil with nitrogen and add organic matter in the amount of roots and stubble left in the soil, thus assisting in maintaining soil fertility.

A crop turned into the soil during warm weather decomposes rapidly, and the plant food liberated by such decomposition may be carried away by leaching or escape as gas if a growing crop is not present to prevent such loss.

A summer green-manure crop should not be plowed down in late summer or early fall unless it is followed with a winter crop to prevent the loss of the plant food liberated during decomposition.

When a winter crop does not follow a summer green-manure crop the summer crop should be allowed to stand through the winter or should be mowed and left on the ground as mulch.

Ordinarily 2 weeks, at least, should elapse after a heavy green-manure crop has been turned down before the succeeding crop is planted.

When hard seed is present in an appreciable amount, as in crotalaria and sweetclover, the seed should be scarified before it is planted.

Washington, D. C. Issued September 1935

SUMMER CROPS FOR GREEN MANURE AND SOIL IMPROVEMENT

By Roland McKee, *senior agronomist, Division of Forage Crops and Diseases, Bureau of Plant Industry*

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INTRODUCTION

THE USE of summer crops for green manure is not as common a practice as the use of winter crops for that purpose. This is for the simple reason that the summer season is the time when most cash crops must be grown. To use the land exclusively for a summer green-manure crop would preclude the possibility of growing a regular summer cash crop. Winter green-manure crops occupy the land at a time that interferes but little, if any, with the regular cash crop and, therefore, ordinarily can be used more economically than summer crops. The use of summer green-manure crops, however, is to be recommended under certain conditions.

Summer crops at once assume great importance when legumes or other crops in rotations for soil improvement are considered, and such practice is recognized as a means of maintaining soil fertility and insuring increased crop yields.

CROPS COMMONLY USED

The summer crops commonly used for green manure and soil improvement are such legumes as alfalfa, red clover, soybeans, cowpeas, velvetbeans, sweetclover, crotalaria, and lespedeza. Other crops, both legumes and nonlegumes, are used to a lesser extent under special or local conditions, as indicated under the several crop headings.

Alfalfa and red clover are used in rotations as cash crops, as crops to turn under for green manure, and as permanent cover crops in orchards; soybeans, cowpeas, and velvetbeans are used in rotations as cash crops, as crops to turn under for green manure, and as crops to grow in combination or intermixed with corn. Sweetclover is used in rotations as a cash crop and as a crop to turn down for green manure; lespedeza (fig. 1) is used as a cash crop in rotations and, to a limited extent, for green manure. Crotalaria (fig. 2) is used exclusively for green manure.

NONLEGUMES FOR GREEN MANURE

While legumes are generally recognized as the most desirable green-manure plants, under certain conditions nonlegumes may be used more profitably. When the period is very short during which the green-manure crop can occupy the land, as is usually the case in truck growing, it is desirable to plant a crop that will make the most growth in the time available. Under such circumstances, Sudan grass (fig. 3) or one of the sorghums often can be used to advantage; or, in certain parts of the South, pearl millet might be a serviceable crop.

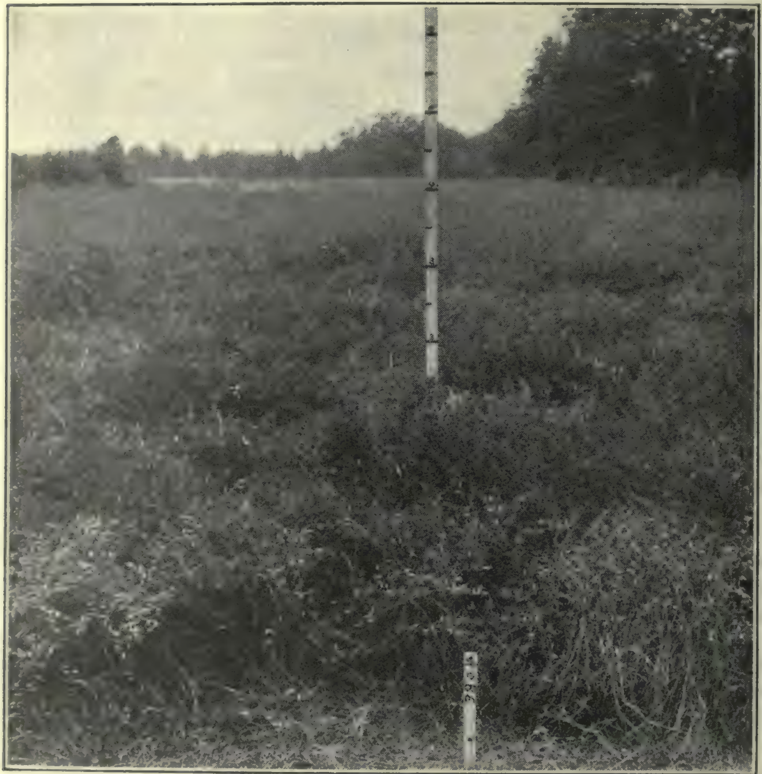

FIGURE 1.—Kobe, a variety of common lespedeza.

In improving poor or worn-out soils, a nonlegume, such as buckwheat, sometimes serves better than any legume. When the objective is to supply organic matter to the soil, the crop that will produce the most growth in the time available should be chosen, whether a legume or a nonlegume.

INOCULATION

Artificial inoculation should be supplied when planting legumes on land that previously has not grown the crop, unless it is definitely known that the soil carries the necessary inoculating organism.

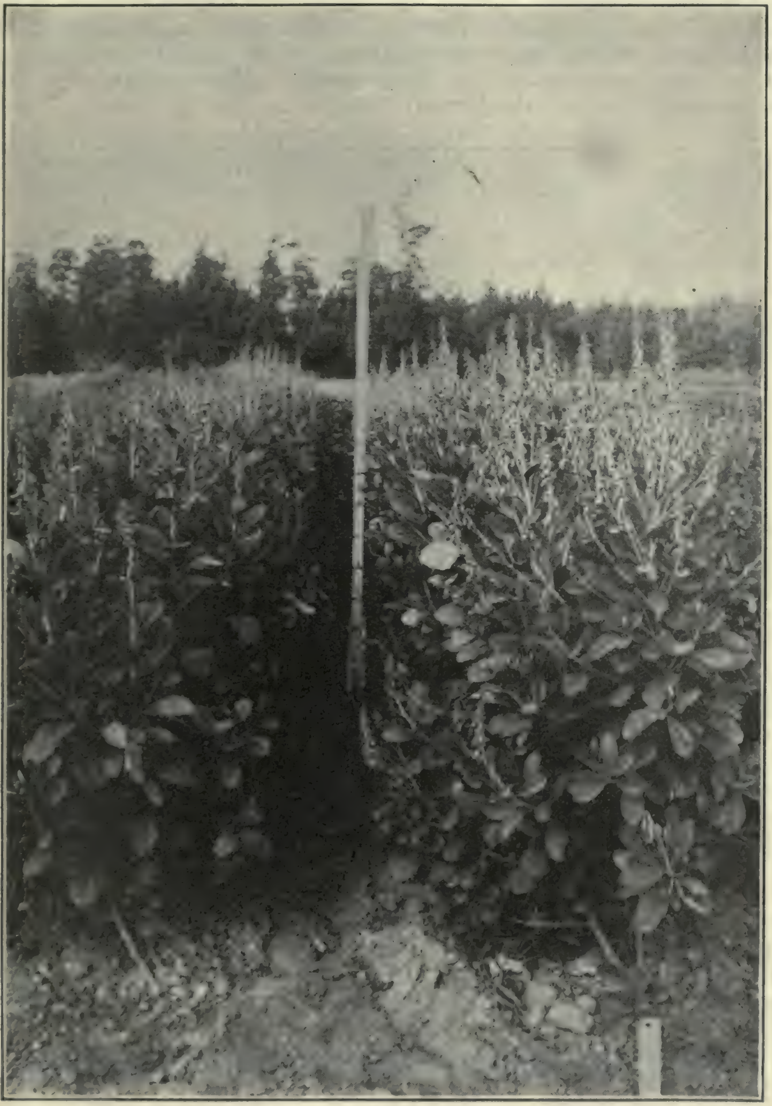

FIGURE 2.—*Crotalaria spectabilis* planted in wide rows.

Whenever possible, a small amount of soil from a local field that has grown a well-inoculated crop the previous year should be mixed with the seed, or 500 pounds per acre of such soil should be spread over the field prior to seeding. It is also advisable to use commercial cultures which can be purchased through seed dealers. Directions for the use of such cultures will be found on the packages.

Florida beggarweed, cowpeas, Deering velvetbeans, crotalaria, lespedeza, and common sesbania usually are naturally inoculated in regions to which they are climatically adapted, and all are inoculated by the same organism.

Alfalfa and sweetclover likewise have a common inoculating organism but, unlike the previous group, often need artificial inoculation when being grown for the first time. This is especially true in the eastern half of the United States.

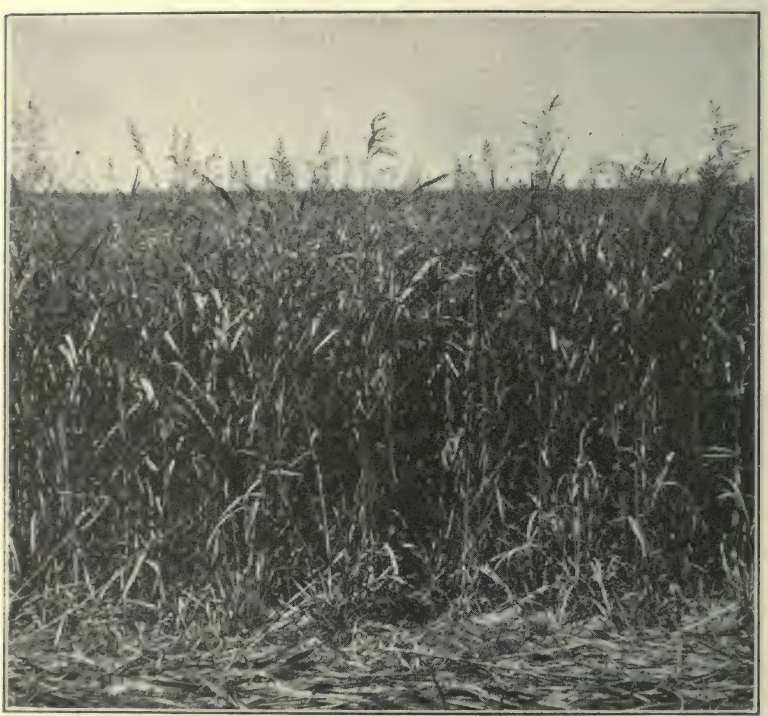

FIGURE 3.—A heavy growth of Sudan grass.

Red clover and soybeans require distinctive inoculating organisms different from those required by any of the other crops mentioned. None of the common legume crops are inoculated by the same organism as the soybean. When this crop is being grown on land for the first time it always requires artificial inoculation. Red clover requires a different organism from the other crops but seldom requires artificial inoculation because of the wide distribution of wild and cultivated clover.

FERTILIZER

Whether commercial fertilizer should be used on a summer green-manure crop can usually be determined by observing the local practice with the same crop when grown for immediate cash returns. Ordinarily heavy growth is desired in a green-manure crop, and when at least a fair growth cannot be attained without the use of fertilizer an amount sufficient to give a good yield should be used.

HARD SEED

Many summer legume crops contain a high percentage of hard seed or seed that will not germinate readily without scarification. All such seed should be scarified before it is planted, if prompt germination is desired. A number of scarifying machines, all based on the principle of scratching or breaking the seed coat, are on the market. Scarification is accomplished in part when seed is threshed or hulled. Hullers with rasp cylinders and concaves usually scarify a high percentage of ordinarily hard seed.

A barrel, as described in Leaflet 107, The Barrel Seed Scarifier, or a concrete mixer has proved to be quite effective and often can be used conveniently when other means of scarifying are not available. Equal parts by volume of seed and stones about three-fourths of an inch in diameter should be placed in the barrel or concrete mixer and revolved slowly for about 1 hour. If the amount of gravel is increased, the time required for scarifying will be lessened. Each year before planting time, seed tests should be made to determine the amount of hard seed and the percentage of germination of the seed that is to be planted. Such tests will indicate in a few days whether or not scarification is necessary.

SEEDING

General information regarding seeding is given in table 1. More specific information is given under each crop heading. Under time of seeding, the designations are necessarily general. Most of the spring-sown plants are summer annuals and should not be planted until all danger of frost is past. The few plants that require late-winter planting are fairly hardy and should be well established before warm weather. The rate of seeding will vary with climatic and soil conditions, but usually should be within the limitations given.

Common lespedeza, Korean lespedeza, alfalfa, sweetclover, and red clover should be seeded in late winter or early spring. The other crops listed in table 1 should not be seeded until all danger of frost is past.

TABLE 1.—*Rate of seeding summer crops for green manure and soil improvement*

Crop	Quantity needed to plant 1 acre		Crop	Quantity needed to plant 1 acre	
	Broadcast or in close drills	In 3-foot rows		Broadcast or in close drills	In 3-foot rows
	Pounds	*Pounds*		*Pounds*	*Pounds*
Alfalfa	15 to 20	3	Red clover	15 to 20	3
Florida beggarweed	15 to 20	3	Common sesbania	25 to 30	4 to 5
Buckwheat	35 to 50	8	Soybeans	60 to 100	20 to 25
Cowpeas	80 to 100	20	Sudan grass	20 to 25	4 to 5
Crotalaria striata	15 to 20	4	White sweetclover	15 to 25	3 to 4
Crotalaria spectabilis	20 to 30	6	Yellow sweetclover	15 to 25	3 to 4
Common lespedeza	15 to 20	3	Deering velvetbeans	100 to 120	25 to 30
Korean lespedeza	15 to 20	3½			

DECOMPOSITION

A green-manure crop decomposes readily when incorporated with moist soil. In warm weather with moisture present almost complete decomposition may take place in less than 6 weeks. Young, succulent material decomposes much more readily than older or mature plants.

Fertility liberated in the process of decomposition should be utilized immediately by growing plants, or it will be lost by leaching or escaping into the air in the form of gas.

These facts should be kept in mind in utilizing green-manure and cover crops or any kind of crop residue.

TURNING UNDER

A green-manure or cover crop may be left on the surface, or it may be incorporated with the surface soil by disking or plowing. When it is incorporated with the soil, care should be taken not to leave the green-manure material in bunches or layers that will not decompose readily. Large quantities of undecomposed material will tend to make the surface soil dry and result in a poor seed bed and a condition unfavorable for good crop growth. When ample moisture is present, a crop completely turned under ordinarily will decompose more rapidly than one left on the surface or only partially turned under. Whether a green-manure crop should be completely turned under, partially incorporated, or left on the surface of the soil should be considered further in connection with (1) maturity of the crop, (2) time of year, (3) length of time that will elapse before the growth period of the succeeding or cash crop, (4) nature of the succeeding or cash crop, (5) type of soil, and (6) moisture supply.

A young succulent plant will decompose more readily than mature material.

In hot weather, decomposition is most rapid and, conversely, in cool weather, is retarded. A green-manure crop turned down in late winter will not decompose so rapidly as one turned down in late spring.

It is desirable to have the crop turned down a sufficient length of time before an annual crop is planted to enable the material to pass through the first stages of decomposition in order that the plant food thus liberated may be available to the growing crop during its early development and rapid-growth period. Seeding a crop immediately after turning under a green-manure crop will sometimes result in injury to the young seedlings. In experimental planting it has been found advisable to let 2 weeks elapse before planting corn and 3 weeks before planting cotton. In the case of permanent crops, such as trees, exact information is lacking, but it is assumed that the green-manure or cover crop should be decomposed if possible just before the rapid-growth period of the permanent crop.

Whether a green-manure crop should be plowed under or worked into the soil lightly when used in orchards depends somewhat on the activity of root growth of the trees at the time of such plowing or cultivation. If the roots are in active growth they should be disturbed as little as possible, but if dormant, deeper cultivation may be given.

Organic matter usually can be incorporated into heavy clay soils without serious danger of loss from leaching, since leaching in such soils takes place slowly. In the case of sandy or porous soils, leaching is rapid, and it is important to have the green-manure material nearly mature and to leave it at the surface so that decomposition and leaching may not be too rapid.

When ample moisture is present and the temperature is sufficiently high for plant growth, decomposition goes on rather rapidly under almost any soil condition. In general, however, decomposition is retarded by leaving the green-manure material on the surface or working it in but lightly or partially.

Other factors, too, are involved, such as the effect on crops of plowing or working the soil at certain times of the year, and these must be given some consideration in handling the green-manure crop.

TYPES OF SUMMER GREEN MANURING

The use of summer green manure should be considered not only from the standpoint of increased crop yields, but also with reference to cash returns in connection with the crop that it is to precede or supplement. If a green-manure crop is to have exclusive use of the land for an entire season its use must be justified by the returns from increased crop yields in subsequent years. Sometimes it is possible to grow a green-manure crop and a cash crop the same season, but more often when a cash crop is grown every year it is necessary to obtain the green manure by interplanting with the main crop or merely by using the residue of the main cash crop to supply the organic matter. The use of the words " green manure " in this way somewhat broadens the usual meaning, but the addition of organic matter to the soil in any way is in effect green manuring and must be considered in a discussion of the subject.

Under this broader definition of the term, there are four types of summer green manuring that need consideration, viz: (1) Using the crops exclusively for green manure, that is, the green-manure crop occupies the land the entire season to the exclusion of any other crop; (2) growing a green-manure crop intermixed with the main crop but subsidiary to it; (3) growing a green-manure crop in midsummer or late summer following a cash crop; (4) using legumes in rotation with other crops and treating the stubble or aftermath of the legume as a green-manure crop.

These several types or kinds of summer green manuring can best be discussed separately.

General experience and the limited experimental data available indicate that the giving over of the entire crop season to the exclusive use of a green-manure crop is seldom profitable. This practice perhaps is justifiable only when the succeeding crop is more or less permanent and the establishment and good growth of the seedlings or young plants are of prime importance. Where early fall seeding of lawns can be practiced or is advised, a summer green-manure crop of soybean, cowpea, or other legume can well be used to prepare the land to receive the grass seeding.

In the South when a summer legume is plowed down in early fall it should be followed with rye or some other winter-growing crop to prevent the leaching of the plant food released in the decaying of the turned-under crop. When a summer green-manure crop is not followed by a winter crop, the summer green manure should not be plowed under green but should be cut in the fall and allowed to remain on the surface as a mulch or should be lightly worked into the soil, so as to delay decay and prevent loss during the winter months.

In northern latitudes there is relatively little leaching during the winter period; consequently it is seldom profitable to grow a crop merely to prevent this relatively small loss. In the case of abandoned or worn-out lands a legume might well be sown to occupy the land more or less permanently, and where seed of a satisfactory legume is available at a reasonable price such a procedure is to be advised. In certain parts of the South lespedeza and crotalaria can be used in this way.

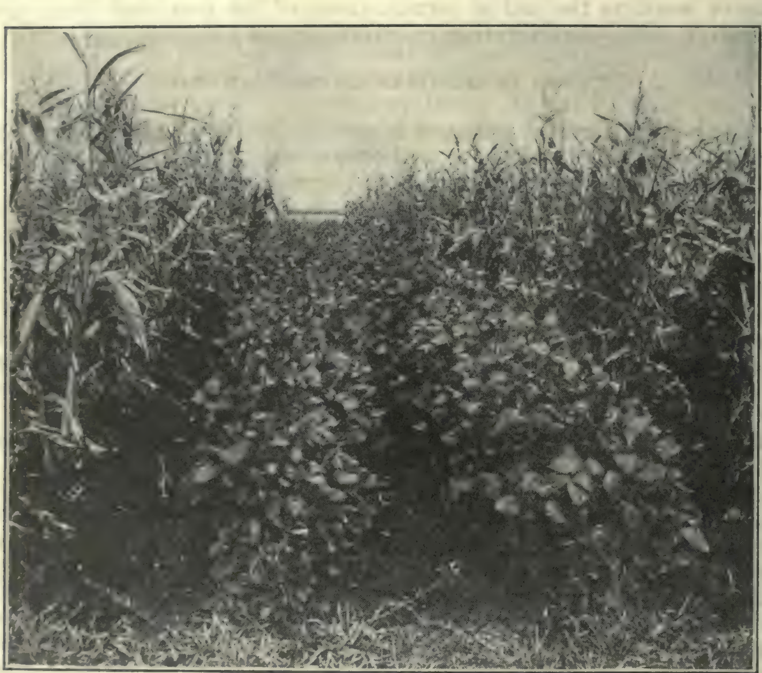

FIGURE 4.—Corn interplanted with soybeans.

When a nonlegume, such as corn, is the main cash crop the use of a legume intermixed in the planting, or interplanted, will furnish valuable organic matter and in part have the effect of a crop rotation. Soybeans and velvetbeans are commonly planted with corn in this way in the Cotton Belt, and the practice is to be recommended (fig. 4).

Sometimes a green-manure crop can be planted in late spring or midsummer following an early cash crop such as wheat, oats, or some truck crop. As to whether a crop thus grown can best be used exclusively for green manure or in part for forage and part for green manure will have to be determined by the probable cash value to the succeeding crops and the value of the forage that might be obtained. Where crotalaria is well adapted it can be used to advantage in this way for a green-manure crop. A good green-manure crop can be assured by broadcast seeding the crotalaria in oats in late spring, which will in no way interfere with the growth of the oats or harvesting them. The seeding of the crotalaria should be fairly late; if the oats are sufficiently small to permit of a light harrowing to cover the crotalaria seed, this is a good practice.

The use of legumes in rotation as one of the regular cash crops is a common practice and one of the most economical ways of maintaining soil fertility and crop production. The stubble of the legume returns to the soil considerable organic matter that is high in nitrogen and that costs practically nothing (fig. 5).

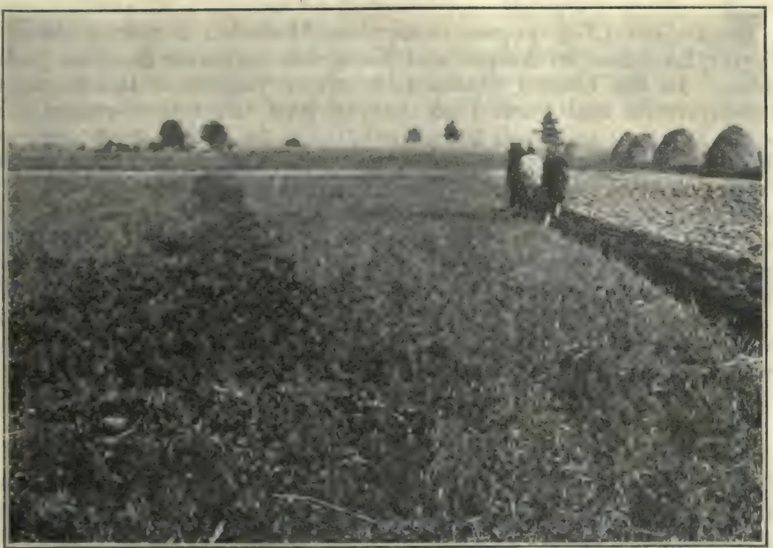

FIGURE 5.—Crimson clover and grain stubble being turned under for soil improvement.

In the South, especially on light soils, if maximum results are to be obtained, when stubble or other crop residue is plowed under in early fall, rye should follow as a winter crop to prevent leaching and loss of the plant food liberated by decomposition.

COMMON ALFALFA

Common alfalfa (*Medicago sativa* L.), a long-lived upright perennial, while primarily a hay crop, is valuable in crop rotation and is used effectively as a green-manure and cover crop. In the irrigated apple orchards of the Rocky Mountains and the Pacific Coast States, it is being used with excellent results as a cover crop, and in the truck-crop areas of the Southwest it has been found to be one of the best crops to precede or rotate with lettuce, cantaloup, or similar crops. When common alfalfa is grown in an orchard, the entire crop should be allowed to remain for mulch or cover. It can be cut at intervals, or allowed to stand and mat down without being cut. Disking the orchard during the fall and winter months is a common practice. This reduces the fire hazard from accumulated dry material, incorporates some of the organic matter with the soil, destroys hiding places or nests of insects and rodents, and puts the ground in shape to facilitate furrowing for irrigation.

In growing common alfalfa in orchards with trees under 4 years old, care should be exercised to see that the trees get sufficient water and plant food. When the trees are older and more deeply rooted there is less danger in this connection. When common alfalfa is grown in orchards or elsewhere for green manure or cover, the time, rate, and method of seeding are the same as when the crop is grown for hay or other purposes.

BUCKWHEAT

Buckwheat (*Fagopyrum esculentum* Moench.) is a very old crop, having been used in Asiatic and European countries from very early times. In the United States, it is grown mostly in the Northeast, Pennsylvania and New York having half the total acreage. Not being exacting as to soil conditions, it can be grown on poorer soils than most crops. It does well on acid soils, and liming for the crop is seldom necessary. For these reasons, it can sometimes be used in preference to other crops for adding organic matter to the soil. Buckwheat is very sensitive to cold and is very easily killed by freezing. Plantings in the northeastern United States should be made the latter part of June or early in July for best results. The rate of seeding should vary with the fertility of the soil. On rich soils 35 pounds per acre is ample, but on poor soils as much as 60 pounds per acre may sometimes be needed.

COMMON SESBANIA

Common sesbania (*Sesbania macrocarpa* Muhl.) is native to North America and extends as far north as Alabama, Georgia, and Arkansas. In the southwestern part of the United States it occurs in abundance on the overflow lands of the Colorado River, and in Louisiana it is common in the rice fields. In recent years this species has come into commercial use as a green-manure crop and is commonly known in the trade under the name "sesbania." Occasionally it is referred to as wild hemp, but this name should not be used, as the name hemp is commonly used for another class of plants. It is an upright annual legume attaining a height of from 6 to 8 feet. In thin stands it is moderately branched, but in thick stands the lower branches either fail to develop or are shed very early and the upper branches are rather light and leafy.

While common sesbania is primarily a subtropical plant, it will mature seed as far north as Washington, D. C. Where sufficient soil moisture is available or when irrigation is supplied, it does exceptionally well in the Southwest, where the atmospheric humidity is very low. It does not thrive so well in the Southeast, where the rainfall is comparatively heavy and the atmospheric humidity high. This difference may, however, be due more to soil difference than to climatic difference, as the soils of the Southwest are very fertile.

Common sesbania makes but little growth in cool weather but grows very rapidly in high temperatures. In northern latitudes slow growth and small yields are to be expected. It is strictly a summer-growing plant.

Available information indicates that common sesbania does best on rich loam soils. It will grow on poorer lands, but it has done rather poorly in limited tests on poor sandy soils.

The only use made of common sesbania is for green manure. It seems to be disliked by livestock and, so far as known, has no value as forage. In the Imperial and Coachella Valleys of California and in the Yuma and Salt River Valleys of Arizona, common sesbania is used for green manure in connection with winter truck crops. It has also proved adapted to the irrigated lands of the lower Rio Grande in Texas. On account of its rapid growth and the heavy tonnage produced, this crop seems well suited for green manure where the land can be given over to this purpose during the midsummer season.

The seed of common sesbania is comparatively small, and 20 pounds per acre should be sufficient under average conditions. The seeding may be done by broadcasting or drilling; the latter method is more economical and usually gives better stands.

It is not uncommon to find nematodes in the roots of common sesbania, but they do not seem to do serious damage to the plant. In fact, plants with nematodes are often strong and vigorous. While little or no damage may be done to common sesbania, succeeding crops may be attacked by the nematodes, and this must be considered in growing any crop that may be subject to nematode attack.

As the organism that inoculates common sesbania seems to be rather commonly distributed throughout the South, artificial inoculation is unnecessary.

COWPEAS

Cowpeas (*Vigna sinensis* (Torner) Savi) are one of the summer crops most commonly used for green manure in the Southern States. The plants are viny or semiviny, depending on the variety, and are fairly leafy. Under most conditions, cowpeas make a good yield of green manure in comparison with other crops and are also valuable both as a forage and seed crop. Adapted to a wide range of soils, they apparently do as well on sandy soils as on clays. Among the best varieties for use in the South are Iron, Victor, Brabham, and Groit. Seeding should not be done until the ground is thoroughly warmed, as all varieties are susceptible to cold. When planted in rows 3 feet apart, about 20 pounds of seed per acre are required; when sown broadcast, 80 to 100 pounds per acre are needed. Cowpeas are subject to attack by nematodes and a bacterial wilt, both of which often may do considerable damage.

If cowpeas have been grown in a locality for many years, the inoculating bacteria are plentiful, and inoculation usually is not necessary. In new regions, however, especially in the North and West, when cowpeas are grown for the first time, the soil should be inoculated from an outside source.

CROTALARIA

Two species of *Crotalaria* have been used for green manure in the United States, *C. spectabilis* Roth and *C. striata* DC. Other species with similar habits have value for this purpose and are used in other parts of the world.

Both *Crotalaria spectabilis* and *C. striata* behave as annuals in the United States except under almost frostless conditions. They are upright and attain a height of from 3 to 6 feet. A warm season is necessary for their best development. They do not start growth until late and make most rapid growth during July and August. Crotalaria is especially adapted for sandy land. The seed should be planted in late spring, from 15 to 30 pounds of seed being used per acre. The latter quantity should be used, especially when the seed is not scarified or when seeding conditions are unfavorable.

Artificial inoculation seems not to be necessary under ordinary conditions. Crotalaria has been used most extensively in the citrus and tung-oil plantings in Florida, but it has also been used in pecan orchards of the Gulf coast area and for general plantings elsewhere. The yield of green manure is comparatively heavy, the plants decompose readily, and the crop seems well adapted for cover and green-manure purposes. As the percentage of hard seed is usually high the seed should be scarified before being planted.

In the lower South, crotalaria can be seeded in oats in late spring and allowed to grow subsequent to the harvesting of the oats; in this way a good green-manure crop is assured at little expense. The crotalaria will make but little growth before the oats are mature and will in no way interfere with harvesting. The oats serve as a nurse crop, keeping down weeds that otherwise would be in competition with the crotalaria during the early and most critical period of its growth.

FLORIDA BEGGARWEED

Florida beggarweed (*Meibomia purpurea* (Mill.) Vail.), an annual, upright, herbaceous plant, attaining a height of 4 to 7 feet, is a native of tropical and subtropical America, occurring as far north as the southern part of the United States, especially in cultivated lands. The plant is leafy above but sparingly so below, and the main stem is sparsely branched. In thick stands the branches are greatly reduced or fail to develop.

In Florida and as far north as southern Georgia and Alabama, it has been used as a regular and volunteer crop. Attempts to grow the crop at a few northern experiment stations indicate that under favorable conditions it will make a fair growth as far north as the Great Lakes States but in northern latitudes it can seldom compete with summer weeds.

Florida beggarweed does best on a rich sandy loam soil but is not exacting in its requirements. It is of particular interest and value on account of its ability to grow on soils that are moderately acid. A moderate rainfall is essential to good growth even though the plants will stand as much drought as the average farm crop. On extremely poor sandy soil, it will do but little unless supplied with commercial fertilizers; on cotton and corn lands that have been regularly fertilized, little or no fertilizer is needed; on lands not previously fertilized, 200 pounds of superphosphate, 75 pounds of muriate of potash, and 50 pounds of sodium nitrate or sulphate of ammonia can be used to advantage.

For green manure, Florida beggarweed serves best on sandy loam soils in rotations where a volunteer crop can be handled. When once established it will volunteer from year to year if seed is allowed to mature. Volunteering can be accomplished by permitting strips through the field to go to seed each year and then harrowing crosswise to scatter the seed, relying on subsequent plowing and cultivating to cover the seed. While good stands will not always result from this method of procedure, it may often be an economical practice. Florida beggarweed does not reseed well except on cultivated land. Cotton growers sometimes object to this volunteering habit, as the mature seed of Florida beggarweed adheres to the lint of the cotton.

Seeding of Florida beggarweed should be delayed until all danger of frost is past. From May 15 to June 20 is recommended for the extreme South. Seed can be sown in early corn at the time of the last cultivation. Hulled seed should be used for seeding when an immediate stand is desired. Unhulled seed will not germinate readily on account of the high percentage of hard seed it contains. When hulled seed is used, from 15 to 20 pounds per acre of scarified seed is sufficient on a good seed bed. If unhulled seed is used, this should be increased to 30 to 40 pounds per acre. As the organism that inoculates Florida beggarweed seems to be present in most southern soils, artificial inoculation is unnecessary.

LESPEDEZA

Common lespedeza (*Lespedeza striata* (Thunb.) Hook. and Arn.) is an annual, spreading or upright leguminous plant attaining a height of 6 to 12 inches on poor soils and of 12 to 18 inches or sometimes more on fertile soils. The stems are small, branch freely in thin stands, and are quite leafy. It is well adapted to the Southeast and is found as an escape throughout the Piedmont and Coastal Plains areas, extending north to and beyond the Ohio River and west beyond the Mississippi River. It is in this general region that the crop is most valuable.

For soil improvement, common lespedeza offers great possibilities. It may be used for green manure, for hay, or for rotating with other cash crops.

While common lespedeza makes but little growth until warm weather and continues growth until fall, it must be seeded early to get good stands. The seed should be sown either broadcast or in close drills, between January 15 and March 15 at the rate of 15 to 20 pounds per acre. When the plants are allowed to stand sufficiently late to mature seed, a volunteer growth will be maintained from year to year. While the root-knot nematode has been reported as attacking common lespedeza, it is practically immune. The organism that inoculates common lespedeza seems to be rather widely distributed, and artificial inoculation will seldom be required.

There are two improved varieties of common lespedeza, known as Kobe and Tennessee No. 76, both of which grow larger than the common form and are to be preferred for use under cultivation.

Korean lespedeza (*Lespedeza stipulacea* Maxim.) is like common lespedeza in general, but differs in its range of adaptation, season of development, and minor plant characteristics. It cannot be used successfully as far south as can common lespedeza, but it has a somewhat farther northern range. It is an earlier maturing, slightly larger growing plant than common lespedeza, with practically identical utilization.

RED CLOVER

Red clover (*Trifolium pratense* L.) has long been known as a valuable crop for soil improvement. Using it in crop rotations is a common practice and often it is used as a summer green-manure crop. It is also used as a combination hay and green-manure crop, which seems to be very practical. The early or first growth is cut for hay and the later or second growth used for green manure. Another way of handling it is to cut the first crop for hay, then harvest a seed crop and return the straw to the land. When only the stubble is returned to the soil, there will be a benefit to the soil from the nitrogen gathered by the nodule-forming bacteria that live on the roots. The fact that red clover has upright growth and heavy yields, together with its fitting so readily into rotations with other crops, makes it one of the best crops for soil-improvement purposes.

In most regions red clover is seeded in the spring, 15 to 20 pounds of seed being used per acre. Because red clover has been grown over such a wide area, the organism that inoculates it is usually in the soil. In new areas, however, artificial inoculation should be practiced.

SOYBEANS

The soybean (*Soja max* (L.) Piper) is an upright-growing legume native to northern China, from which region it was introduced into the United States early in the nineteenth century. While the crop is grown primarily for seed, it is used extensively for forage and soil-improvement purposes. In the United States, it is grown mostly east of the ninety-ninth meridian or a line passing through the middle of the Dakotas and south through central Texas. When soybeans are used for a green-manure crop, late-maturing varieties usually will give the largest yields; when used as a regular crop in rotations, varieties should be selected that will give high yields of seed or hay, as the grower may desire. For green-manure, the crop should be sown broadcast or in close drills, from 60 to 100 pounds of seed being used per acre, depending on the size of the seed, which varies with varieties. When soybeans are sown on land where the crop has not been previously grown, inoculation is advisable. Where the crop has been grown in previous years, inoculation is not necessary.

SUDAN GRASS

Sudan grass (*Sorghum vulgare sudanensis* (Piper) Hitchc.) is an easily grown nonlegume whose habit of rapid growth makes it a very suitable plant for green manure when the period in which such a crop can be used is very short. Sudan grass belongs to the sorghum group of plants, but it is only moderately coarse and is adapted to practically all parts of the United States. The culms or stems are upright, attaining a height of from 3 to 5 feet and a diameter equivalent to that of an ordinary lead pencil or less. Such a plant is especially serviceable in connection with truck-crop growing where the summer period between crops usually must be short. The seed should be sown in close drills or broadcast, 20 to 25 pounds of seed being used per acre. The time of turning down should be determined with reference to the time of planting the succeeding crop and not with reference to the stage of development of the Sudan grass. Ordinarily very succulent Sudan grass will decompose rapidly, and a short period after its turning under, the soil will be in condition to receive the succeeding crop. When the plants are more mature, a longer time is required. Mature Sudan grass plants turned into the soil will reduce the available nitrates for a time, and such material should never be used except when ample nitrogen fertilizer is applied or when a long period can elapse before it is necessary to have available the nitrogen that already is present in the soil.

SWEETCLOVER

There are two species of sweetclover that are used as summer green-manure crops in the United States. These are white sweetclover (*Melilotus alba* Desv.) and yellow sweetclover (*M. officinalis* (L.) Lam.). These are upright-branching, leafy, biennial legumes, in thick stands having the appearance of alfalfa. The first year of seeding they make a growth of 12 to 24 inches, depending on moisture and soil conditions. In the second year a height of from 4 to 5 feet usually is attained. Both these species need lime and for this reason cannot be grown successfully in most parts of the eastern half of the United States unless this need is supplied. In the Corn Belt, white sweetclover has been especially useful as a soil-improving crop. Large increases of corn and other crops have followed its use as a green-manure crop and as a hay crop in rotations.

Inoculation is one of the important factors in success with both white sweetclover and yellow sweetclover. In the alfalfa region west of the Mississippi River, wherever alfalfa inoculates naturally, these crops will not need artificial inoculation, but in most areas east of the Mississippi River artificial inoculation is essential. The seed should be sown on well-prepared firm ground, 15 pounds of scarified seed or 25 pounds of unscarified seed being used per acre. Seeding can be done any time from fall to early spring. In the fall or winter unscarified seed should be used, but in the spring scarified seed gives the best results. Spring broadcast sowings should be covered with a harrow; fall or winter sowings should be broadcast and given no further treatment. The heavy top growth and large deep-penetrating roots make both these crops excellent for green manure.

DEERING (FLORIDA) VELVETBEANS

The Deering (Florida) velvetbean (*Stizolobium deeringianum* Bort.) is a vigorous-growing leguminous annual plant which, under favorable conditions, attains a stem length of 40 feet or more. Most varieties are viny, but a bush form has been developed. It is semitropical in its requirements and is adapted only to the southern part of the United States. While Deering velvetbeans make excellent feed for livestock, when cut in bloom they are difficult to handle for hay and are seldom used for this purpose. However, they are grown for the seed crop and used in rotations to improve soil. Velvetbeans are one of the best crops for use on sandy lands and can be used to advantage to maintain fertility. Because velvetbeans are hardy, yield heavily, and decay readily, they make an excellent green-manure crop.

The Deering velvetbeans should not be sown until the soil is well warmed, or a little later than the time for planting corn. Seeding in wide rows is recommended and will require from 25 to 30 pounds of seed per acre. As the organism that inoculates Deering velvetbeans is present in the soils of the South, artificial inoculation is unnecessary. The root knot nematode does no damage to this crop, and so far as known all varieties are immune. When velvetbeans are grown for seed it is essential to plant them with a supporting crop such as corn, which insures a free circulation of air and prevents the flowers from decaying without setting seed.

WEEDS

Weeds usually are thought of as plants that should be destroyed, but it should be kept in mind that much of the vegetation that is commonly termed weeds contributes large quantities of organic matter to the soil. Whenever weeds can be utilized for green manure without sacrificing needed ground moisture and plant food, their presence may be an advantage rather than a detriment, a fact which should be kept in mind in handling weeds in connection with crop production.

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